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ORIGINAL ARTICLES.

I.—*Millestroma*, a Cretaceous Milleporoid Coral from Egypt.

By J. W. Gregory, D.Sc., F.G.S., of the British Museum (Natural History).

(PLATE XIII.)

THE wide geographical distribution of the Milleporidæ is a clearer proof of the geological antiquity of the group than any evidence yielded by palæontology. For *Millepora* has no known Mesozoic or certain Lower Cainozoic representative, and is thus separated by a great gap from the Palæzoic Hydrocorallinæ, whence it is probably descended. But the Stromatoporoids disappear at the end of the Palæozoic, and I am not aware that any coral has been described which helps to connect that group and the Cainozoic Milleporids.

The question is complicated by the difficulty of distinguishing between the skeletons of those Bryozoa, Hydrozoa, and Anthozoa which consist of masses of parallel tubes.[1] In each of these groups there are genera in which the skeletal structures consist of bundles of long, narrow, cylindrical or prismatic tubes, which are of two sizes, and are divided into chambers by flat platforms or tabulæ. The problem how to determine to which group a particular fossil with these characters may belong has not yet been solved. This is not surprising since the same doubt also occurs respecting some living species. Thus, according to most authors, *Heteropora pelliculata*, Waters, is a Bryozoan; but according to Wentzel[2] it is a Favositid. In regard to the recent forms, even if we have no knowledge of the soft parts, we can get some light from the histological structure of the skeleton. But this clue is lost in the case of most of the fossils; for as a rule the calcareous skeleton is perforated by numerous pores and canals, so that it is open to attack by solvents; hence the hard tissues have generally been dissolved and redeposited in a crystalline form. During this process the

[1] The difficulty presented by these multitubular fossils I have previously stated in the "Catalogue of the Jurassic Bryozoa" (Brit. Mus., 1896), pp. 3–6.

[2] J. Wentzel, "Zur Kenntniss der Zoantharia Tabulata": Denk. Akad. Wiss. Wien, vol. lxii (1895), p. 496. The species is referred to as *H. Neozelanica*.

intimate structure has been completely obliterated. Accordingly it is often quite impossible to come to any final decision as to the affinity of such a fossil; we have to be content with temporarily assigning it to one of the three groups, according to the balance of probabilities afforded by a series of characters, none of which are of absolute value.

The collection of Egyptian fossils recently sent for determination to the British Museum by Capt. H. G. Lyons, R.E., includes one interesting fossil which illustrates this difficulty. It comes from the Turonian limestones of Abu Roasch, near Gizeh. It consists of an irregularly ovoid mass, formed by a thick encrustation round a gastropod, probably a *Nerinæa*.[1] A preliminary external examination left me quite in doubt whether the fossil was a Hydrocoralline, an Alcyonarian, or a Bryozoan allied to *Heteropora*. Unfortunately a good deal of the interior of the coral has been silicified; and in the siliceous layers (the dark band of Pl. XIII, Fig. 1*b*) the structure has been almost entirely obliterated. Sufficient, however, is left to show that the fossil has the following characters:—

1. The skeleton, although apparently tubular, is really reticular, being composed of vertical pillars connected by intermediate plates.
2. The interspaces appear on the surface as a series of pores.
3. The pores lead down to interspaces which, owing to the connection of the pillars by more or less vertical laminæ, appear tubular.
4. The pores and apparent tubes are arranged quite irregularly, or in small cyclo-systems, or in linear series separated by branching, radial grooves.
5. The "tubes" are crossed by tabulæ.
6. The skeleton is traversed by short, broad, flexuous, horizontal canals.

The reticular skeleton and the canal system both preclude the reference of the fossil to the Bryozoa: this conclusion is supported by the cyclo-systems, which resemble those of the Cœlenterata rather than of the Bryozoa. So the fossil is limited either to the Hydrozoa or Anthozoa. It is unnecessary to refer to the characters which differentiate this fossil from most of the subdivisions of the two groups. If the fossil be an Anthozoan, it is clearly an Alcyonarian allied to *Heliopora*; and if an Hydrozoan it is obviously one of the Hydrocorallinæ. At first sight the specimen appears to resemble the Alcyonarians, owing to the compactness of its walls and the tubular structure of the whole colony. There is none of the extremely loose, vesicular tissue and abundantly ramified, irregular canal system of such Hydrocorallines as *Millepora* and *Sporadipora*. To illustrate the characters of two typical members of the Alcyonarian and Hydroid corals figures have been given on the plate of sections of *Heliopora* and *Sporadipora*. Contrasting them we find the following differences:—

[1] *Nerinæa* has been recorded from this locality and horizon by Walther, "L'Apparition de la Craie aux environs de Pyramides": Bull. Inst. Egypt, ser. 2, No. 8 (1888), pp. 6, 7.

	Sporadipora.	*Heliopora.*
Septa	No trace.	Rudimentary or clearly developed.
Micropores	Cyclo-systems.	Irregular.
Intermediate tissue between macropores	Spongy.	Tubular.
Canal system	Ramified, extensive.	Short and simple.

This set of characters is not at once decisive as to the affinities of the fossil; for, according to the two last, it more resembles the Alcyonarians, and, according to the two first, it is nearer to the Hydrozoa. But the two first characters appear to be by far the more important. *Heliopora*, *Heliolites*, and *Polytremacis* have all well-recognizable septa, and there is no cyclic arrangement of the micropores. In the Hydrozoa the absence of mesenteries leads to the complete absence of true septa, although in some cases the elongation of the micropores leads to the macropores being surrounded by radial laminæ; but these "pseudosepta" are external to the zooids, instead of a whole radial series being formed within a single zooid. The apparent compactness of the walls between the cavities in this fossil is probably exaggerated by the secondary changes: thus Fig. 1*e* shows that a series of small, dog-tooth like, crystals of calcite spring from the tabulæ and the walls. These crystals show that the whole skeletal tissue has been dissolved and redeposited. The definiteness of the walls is, therefore, not necessarily an original character. In fact, the apparently tubular structure of the "cœnenchyma" or intermediate tissue is misleading, for closer study (see Fig. 1*e*) shows that the skeleton is reticular and not really tubular. The vertical interspaces act as tubes, but these are formed by the growth of the vertical, trabicular pillars, and not by the calcification of a tubular membrane.

Hence even when compared with recent corals representing the two subclasses of Cœlenterata, there seems no doubt that the Egyptian fossil is a Hydrocoralline. And this view is established, almost conclusively, by a comparison with the Palæozoic forms. The general aspect of the fossil, with its massive, encrusting habit, its prominent blunt knobs, and its irregular, perforated surface, is strikingly stromatoporoid. Microscopic study of sections shows that in spite of the absence of the concentric lamination which is such a conspicuous feature in the Stromatoporidæ, the essential structure is the same.

The work of Professor Nicholson[1] has shown that the Stromatoporidæ may be divided into two groups, one of which presents points of resemblance to the Hydractinians, while the other reminds us rather of the structures found in the Milleporidæ. From the former section, including the Actinostromidæ and the Labechiidæ, this fossil differs by the presence of the functional zooidal tubes, a character which also serves to separate it from the Hydractinians. From the Stylasteridæ it differs by its massive habit, by the reticular structure of the cœnenchyma, and by the absence of the extensive

[1] H. A. Nicholson, "A Monograph of the British Stromatoporoids," pt. i (1886), p. 71.

canal system, which ramifies through the broad areas of porous, vesicular tissue that separates the gastrozooids. The massive growth, although a character of little importance, helps to separate the fossil from the Stylasteridæ. The only remaining available groups in which the fossil may find a home are the Milleporidæ and the milleporoid section of the Stromatoporidæ. To which of these it should be referred is not very easy to decide. If we abstract from Moseley's[1] diagnosis of the Milleporidæ all the characters which depend on the hard parts, we find that he states them as follows:—The cœnosteum is irregular, arborescent or incrusting; it is composed of a thin, superficial living layer, lying over dead, earlier-formed layers. The pores have no styles, and are divided into vertical series of chambers by tabulæ; the dactylozooids are usually irregularly arranged, but a circle of them may occur around a gastrozooid.

There is nothing in this series of characters to exclude the Egyptian fossil from the Milleporidæ. It differs, however, from *Millepora* in two ways: the pores are less unequal in size, and a transverse section shows none of the broad open cavities of the gastrozooids. In the second place, the walls around the interspaces in the corals are more compact and narrow. The specimen agrees more nearly with the milleporoid group of Stromatoporidæ owing to the presence of the long, vertical pillars, the linear series of pores, separated by branching grooves, and the more equal size of the pores. In the presence of occasional cyclosystems it agrees, however, again with the Milleporidæ.

Among the Stromatoporidæ, it agrees most closely with the Idiostromidæ, and especially with the genus *Hermatostroma*, which has no axial tube, and in which we see the beginning of the reduction of the concentric, horizontal laminæ, that are so conspicuous in the typical Stromatoporoids.

I therefore regard the fossil as one of the missing links between the Palæozoic Milleporoid Stromatoporoids and the Cainozoic Milleporidæ, and therefore propose for it the name *Millestroma*. The species is named after the author whose work has placed our knowledge of the Palæozoic Hydrocorallines on a sound basis.

Family MILLESTROMIDÆ.

Characters.—Cœnosteum massive, encrusting. Definite zooidal tubes present. The cœnosteum is composed of reticular tissue with abundant tabulæ, but otherwise no well-developed horizontal laminæ. Micropores (dactylopores) usually irregular, linear, or in cyclosystems. No principal axial tube.

Genus Millestroma, nov.

Diagnosis.—Cœnosteum massive; skeletal framework irregular, but forming a series of branching, anastomosing tubes. The horizontal or concentric laminæ are rudimentary, but tabulæ are

[1] H. N. Moseley, "Report on certain Hydroid, Alcyonarian, and Madreporarian Corals": Rep. Chall. Exped., Zool., vol. ii, pt. 7, p. 92.

well developed. The pores are mostly irregular in distribution, but some occur in small cyclo-systems and others in linear series, separated by sinuous, branching depressions. Canals short and broad.

Distribution.—Cretaceous: Egypt.

Millestroma Nicholsoni, nov.

Diagnosis.—Cœnosteum ovoid, formed of a thick encrustation. The surface is marked in places by low humps and knobs; otherwise it is smooth. Cyclo-systems widely scattered; the macropore (gastropore) is not much greater than the micropores (dactylopores), of which there are usually six or seven in a system. The surface is also marked by irregular, sinuous, radial valleys; on the ridges between them the pores are often linear in arrangement. Tabulæ abundant. The radial pillars are irregular in course.

Dimensions.

Length of cœnosteum	83 mm.
Diameter of cœnosteum	40 mm.
Diameter of pores	about ·15 mm.

Distribution.—Turonian: Abu Roasch, near Gizeh, Egypt; Coll. Geol. Surv. Egypt, No. 51.

Description of Figures.—Pl. XIII, Fig. 1*a*, half of the cœnosteum, nat. size, showing the knobbed surface (*a*) and the sinuous grooves (*b*); Fig. 1*b*, transverse section across the same specimen, nat. size, showing the gastropod which forms the nucleus of the cœnosteum; Fig. 1*c*, part of the surface of the same specimen, × 8 diam., showing a cyclo-system at *a* and a weathered area at *b*; Fig. 1*d*, part of a horizontal section across the same specimen, × 8 diam., showing the flexuous horizontal canals at *c*; Fig. 1*e*, part of a vertical section across the same specimen, × 8 diam., showing the irregular pillars (*p*), the absence of concentric, horizontal laminæ, the abundant tabulæ (*t*), and the secondary crystals of calcite (*c*).

Affinities.—This fossil most nearly resembles in its general characters the Stromatoporoid described by Nicholson as *Hermatostroma*.[1] With this genus it agrees in the presence of the horizontal flexuous tubes (cf. Nicholson, op. cit., pt. i, 1886, fig. 16, p. 106); in the presence of the branching and somewhat irregular vertical pillars (cf. Nicholson, op. cit., pt. i, p. 42, fig. 1, B, and pt. iv, pl. xxviii, fig. 9, with Pl. XIII, Fig. 1*e*); and with the linear series of pores, separated by irregular, somewhat radial grooves (cf. Nicholson, op. cit., pt. iv, pl. xxviii, fig. 13). *Hermatostroma*, however, has not the cyclo-systems shown on Pl. XIII, Fig. 1*c*; and *Millestroma* has not the well-developed concentric laminæ formed by horizontal "arms" from the vertical pillars. In both these respects the genus resembles *Millepora* more than the Stromatoporidæ. Cyclo-systems resembling those of this specimen are shown by Moseley in a specimen named *Millepora nodosa*. *Millestroma* is therefore an intermediate form between the Palæozoic and Cainozoic Milleporoid Hydrocorallinæ.

[1] H. A. Nicholson, "A Monograph of the British Stromatoporoids," pt. i (1886), p. 105.

EXPLANATION OF PLATE XIII.

FIG. 1. *Millestroma Nicholsoni*, nov. Turonian: Abu Roasch, Egypt. Fig. 1*a*, half of the cœnosteum, showing the knobbed surface (*a*) and the sinuous grooves (*b*); nat. size. Fig. 1*b*, transverse section across the same specimen, showing the gastropod which forms the nucleus of the cœnosteum; nat. size. Fig. 1*c*, part of the surface of the same specimen; × 8 diam. (*a*, cyclosystem; *b*, weathered part of the surface, showing reticular structure of the cœnosteum). Fig. 1*d*, part of a horizontal section across the same specimen; × 8 diam. (*e*, horizontal canals). Fig. 1*e*, part of a vertical section across the same specimen; × 8 diam. (*p*, pillars; *t*, tabulæ; *c*, calcite crystals).

FIG. 2. *Sporadipora dichotoma* (Mos.). Part of a transverse section through the margin of a cœnosteum, cutting the marginal zooids vertically; × 8 diam.

FIG. 3. Ditto, part of another section from the same, showing the central zooids cut transversely, and the extensive vesicular tissue; × 8 diam.

FIG. 4. *Heliopora cærulæa* (Ell. & Sol.). Part of a transverse section across the central part of a corallum, showing a large gastropore; × 8 diam.

FIG. 5. *Hermatostroma episcopale*, Nich. Devonian: Devonshire. Part of a vertical section showing the pillars and tabulæ; × 8 diam. (After Nicholson.)

II.—Notes on the Correlation of the Lower Carboniferous Rocks of England and Scotland.

By William Gunn, F.G.S., of H.M. Geological Survey of Scotland.

THE substance of the following paper was given at a meeting of the Geological Society of Edinburgh on January 20th this year. Its object is to show that the group of Lower Scottish Limestones about Dunbar and round the Midlothian Coalfield does not represent any part of the Mountain Limestone of Yorkshire, but is the equivalent of the upper part of the Yoredale Series of Phillips, while the Edge Coals and Upper Limestones of Midlothian represent a series of beds which in Yorkshire and Northumberland lie above the true Yoredale Series of Phillips, and which were included by him in the Millstone Grit. It necessarily follows from this correlation that the lower part of Phillips' Yoredale Series, together with the Scar or Mountain Limestone of Yorkshire, are represented in Scotland by the Calciferous Sandstone Series, which is mainly a fresh-water deposit.

This correlation of the Lower Carboniferous rocks of the North of England with those of Scotland was determined in the year 1881, after an examination of parts of the coast of Haddingtonshire and Berwickshire in company with two of my colleagues, Mr. H. H. Howell, now Director of the Geological Survey, and the late Mr. W. Topley, who both accepted at the time the general views here stated. Mr. Topley thought them of so much importance that he wished to join with me in writing an elaborate paper on this correlation, and I drew up some notes on the subject, but for various reasons the paper was never completed or published. However, the principal results have been from time to time orally communicated to several of my colleagues.

To illustrate the paper four vertical sections are given representing the rocks below the Millstone Grit, each section being drawn to the scale of 600 feet to an inch. The most southerly of these gives the succession of beds from the top of Ingleborough down to the

basement conglomerate which rests unconformably on the highly inclined Silurian rocks. The lower part of the section is composed of a solid mass of limestone, 600 to 700 feet in thickness, while the upper part consists mainly of an alternating series of sandstones, shales, and limestones, to which Phillips gave the name of Yoredale Rocks, because he considered they were typically developed in Yoredale (Wensleydale). In this and the other sections the limestones are particularly marked, because it is by means of them principally that the rocks in different places are correlated. The Yoredale Series, then, in the Ingleborough section ranges from the Hardraw Limestone up to the highest limestone—the Main or Twelve-Fathom—but two of the limestones generally occurring elsewhere are wanting in this section, so that it is certainly not a typical one of the Yoredales. Above the Main Limestone here there occurs a thickness of 100 to 120 feet of shale, and the hill is capped by coarse Millstone Grit.

The Wensleydale section is mainly that proved in Keld Heads Mine between Leyburn and Redmire. It will be noticed at once that the Yoredale Limestones are here both thicker and more numerous than at Ingleborough. Four of the limestones are each about 60 feet in thickness, whereas only the Main Limestone on Ingleborough attained this thickness. The two additional limestones are the Underset and the thin limestone next below. It should be stated that the Underset is here abnormally thin, it being usually about twice the thickness given. The 'Fossil' Lime, on the other hand, is usually only about one-half of the thickness here given, so it must be understood that the section does not stand for the whole of Wensleydale. The Main Limestone is often, perhaps generally, considerably more than 60 feet thick; in fact, it obtained the name of 'Twelve-Fathom' because it approximates to 72 feet in thickness. The upper part only of the Mountain Limestone is to be seen in Wensleydale, and its total thickness here is unknown, but it has already, as far as its upper members are concerned, begun to admit intercalations of sandstone and shale, and thus to approximate in character to the Yoredale Series above. In the dales to the north of Wensleydale somewhat similar sections may be obtained, and therefore it is unnecessary to give a detailed account of each. In the first valley, that of Swaledale, the section is very like that of Wensleydale, except that some of the limestones are thinner. In Teesdale we find that the Middle Limestone has separated into three limestones known as Scar, Cockleshell, and Singlepost Limestones, while nearly all the Yoredale Limestones, except the Main, are considerably thinner than in the dales farther south. Several comparatively thin limestones represent the upper part of the Great Scar Limestone of Ingleborough, while the lower part is a solid mass of about 200 feet in thickness, known locally as the Melmerby Scar Limestone. Below this is a variable but not thick mass of basement conglomerate, resting on the Silurian rocks which are exposed in the valley between the High Force and Caldron Snout. Not many miles to the west, in the Pennine escarpment, a thick series of sandstones occurs

below the Melmerby Scar Limestone, so it is evident that the floor on which the Carboniferous rocks were deposited was a very uneven one.

The section in Weardale is very similar to that in Teesdale, except that the Lower Carboniferous rocks are not reached.

When we reach Northumberland we find that the Mountain Limestone of Ingleborough is divided by intercalations of sandstone and shale so as to resemble in character the Yoredale Series above. This was long ago pointed out by Phillips, who says:—"The principal changes, as we proceed northward, appear to happen in the lower part of the limestone group, which loses its individuality, by admitting between its beds a constantly increasing quantity of mechanical admixtures, and at length becomes a subordinate feature in a country which has the characters of a coalfield."[1] As we proceed from South to Mid-Northumberland, while the upper or Yoredale Limestones are generally persistent, the lower limestones representing the Great Scar gradually become thinner and less important, and in many cases disappear entirely, so that eventually we find that nearly all the important limestones are in the upper or Yoredale Series. The work of my colleagues on the Geological Survey, as given in the published maps, is the authority for this part of Northumberland.

For Mid-Northumberland reference may be made to the admirable memoir by the late Mr. Hugh Miller on "The Geology of the Country around Otterburn and Elsdon" (1887), in which the announcement was made (see p. 5) of the identity of the Redesdale Limestone with the Dun Limestone of North Northumberland. Mr. Miller and myself had many conferences on the correlation of the Lower Carboniferous rocks, and he entirely concurred in the main results embodied in this paper. In this district the next limestone above the Redesdale is called the Fourlaws, and both these limestones traced into South Northumberland are found to lie far below the true Yoredale Limestones, and they therefore are portions of the Great Scar.

The North Northumberland section, somewhat generalized, is represented in the third column where the Dryburn Limestone is the uppermost of the Yoredales. Coals occur throughout the series down to the Fell Sandstones, but are omitted generally for the sake of clearness. It will be seen that the principal limestones fall into two natural groups, in the upper of which the limestones are numerous and pretty frequent (down to the Oxford), while several hundred feet lower come the Woodend and the Dun Limestones. Below these is the group containing the Scremerston Coals, 800 to 900 feet thick, in which also limestones occur, but they are always thin (from 1 to 4 feet each), and are for the most part plant-limestones of an estuarine or fresh-water character. Underlying the coals is a thick sandstone group—the Fell Sandstones—and at the bottom of the section is a portion of the Lower Carboniferous group called

[1] Manual of Geology, p. 165 (1855).

Tuedian Beds by the late Mr. Tate, of Alnwick, on account of their being characteristically developed along the Tweed. In 1856 Mr. Tate described these beds as consisting of grey, greenish, and lilac shales, sandstones, slaty sandstones sometimes calcareous, thin beds of argillaceous limestone and chert, and a few buff magnesian limestones. *Stigmaria ficoides*, *Lepidodendron*, coniferous trees, and other plants occur in some parts of the group, but there are no workable beds of coal. The fauna consists chiefly of fish-remains, Modiolæ, and Entomostraca. Generally fresh-water and lacustrine conditions are indicated.[1] The thickness of this series along the River Tweed from Carham to Berwick must be between 2,000 and 3,000 feet, and there is no doubt that it is the equivalent of the lower part of the Calciferous Sandstone of Scotland. Sedgwick seems to have been the first to point out the true position of these rocks in the Carboniferous formation in his address to the Geological Society in 1831; and in notes supplied by him for the third edition of De la Beche's Geological Manual he expresses the opinion that the Carboniferous Red Sandstone of the Tweed is superior to the Old Red Sandstone, and is about of the age of the Great Scar Limestone of Yorkshire and Cross Fell.[2] The natural inference from this would be that the limestones above the Scremerston Coals belong to the Yoredale Series, and it will be seen that this is so far true that *most* of the marine limestones belong to that series, viz. those from the Dryburn to the Oxford inclusive. This set of beds is thinner altogether here than in Wensleydale, but the difference is principally in the limestones, which in Wensleydale amount to about 300 feet, while in Northumberland they are not much more than half that thickness.

Among the sandstones and shales that come between the Oxford and the Woodend Limestones, occurs a marked band of oil shale which is very constant in North Northumberland. It contains remains of fishes, plants, and Ostracoda, and will be met with again in the Scottish section.

In the Northumberland section, No. 1 Limestone is the Dryburn Limestone of Lowick and the Ebb's Snook Limestone of Beadnell, and is called further south in Northumberland the Ten-Yard Limestone. It is the Main or Twelve-Fathom Limestone of Wensleydale and Swaledale, the Great Limestone of Teesdale and Weardale, and is the uppermost member of Phillips' Yoredale Series.

No. 2 Limestone is called at Lowick the Low Dean, and at Scremerston the Sandbanks Limestone, while generally in Mid-Northumberland it receives the name of the Eight-Yard Limestone. It is called in North-West Yorkshire the Underset Limestone, and in Teesdale and Weardale the Four-Fathom.

No. 3 Limestone is the Acre Limestone of Lowick, where it is also sometimes called the Dunstone (which name must not, however, be confounded with the Dun Limestone, the lowest of the marine

[1] Proc. Berwickshire Nat. Field Club, vol. iv, p. 151.
[2] De la Beche, Geological Manual, 1833, pp. 391, 392.

limestones). Further south it receives the name of the Six-Yard Stone, and in Weardale and Teesdale it is called the Three-Yard. It is the Little Limestone, 12 feet thick, in the Wensleydale section.

No. 4 Limestone is the Eelwell of Lowick and the Main Limestone of Beadnell and North Sunderland, and farther south in Northumberland it is called the Nine-Yard. In Weardale and Teesdale it is the Five-Yard. and in Swaledale it goes by the name of the Third Set of Lime. It is the 'Fossil' Lime of Wensleydale.

Now it is these four limestones, with the intermediate strata, that form the group of limestones at Cat Craig, near Dunbar, which is the lower division of the Carboniferous Limestone Series of Scotland, and therefore these marine limestones of Scotland represent only the upper part of the Yoredale Series of Phillips.

The limestones numbered one to four have been traced almost continuously for nearly 100 miles, and we are certain of their identity, but the limestones below these have not been so traced, and there is some uncertainty about their exact equivalents. It seems most probable, however, that the six comparatively thin limestones, from 5 to 10 feet each, between the Eelwell and the Oxford, represent the Scar, Cockleshell, Singlepost, and Tynebottom Limestones of Weardale and Teesdale, and that the Oxford is on the horizon of the Hardraw Scar, or lowest bed of Phillips' Yoredale Series of Limestones. This much is certain, that the Woodend and the Dun Limestones are far below this horizon, and represent portions of the Mountain Limestone or Great Scar Limestone of Ingleborough. The Woodend is called in the Alnwick district the Hobberlaw Limestone, and in the Otterburn and Redesdale districts the Fourlaws Limestone, while the Dun is identical with the Redesdale Limestone. In Scotland generally these marine limestones below the Eelwell are represented by the estuarine Calciferous Sandstone Series. We have, however, a narrow strip of Lower Carboniferous rocks some six miles in length north of the Tweed, along the coast between Berwick and Burnmouth, and here most of the beds below the Eelwell can be observed, though the section near Berwick is a good deal faulted. Between the pier and the Fisherman's Haven the Eelwell, repeated by faults and folds, occurs four times over, the Oxford then is faulted against it, and in the area bounded by faults at the Bay of the Burgess' Cove occurs a set of beds of Tuedian-like aspect on the Oil Shale horizon. Northwards from this is a pretty continuous section from the thick sandstone above the Woodend Limestone down to the genuine Tuedians, which, with a steep reversed dip, are faulted against the Silurian rocks at Burnmouth. The Woodend and the Dun Limestones are thinner here than they are generally in Northumberland. The Dun or Lamberton Limestone may be followed along the coast for nearly three miles, and below it are found some at least of the Scremerston Coals, which were formerly worked at Lamberton, but were found to be poor and thin in comparison with the same seams south of the Tweed.

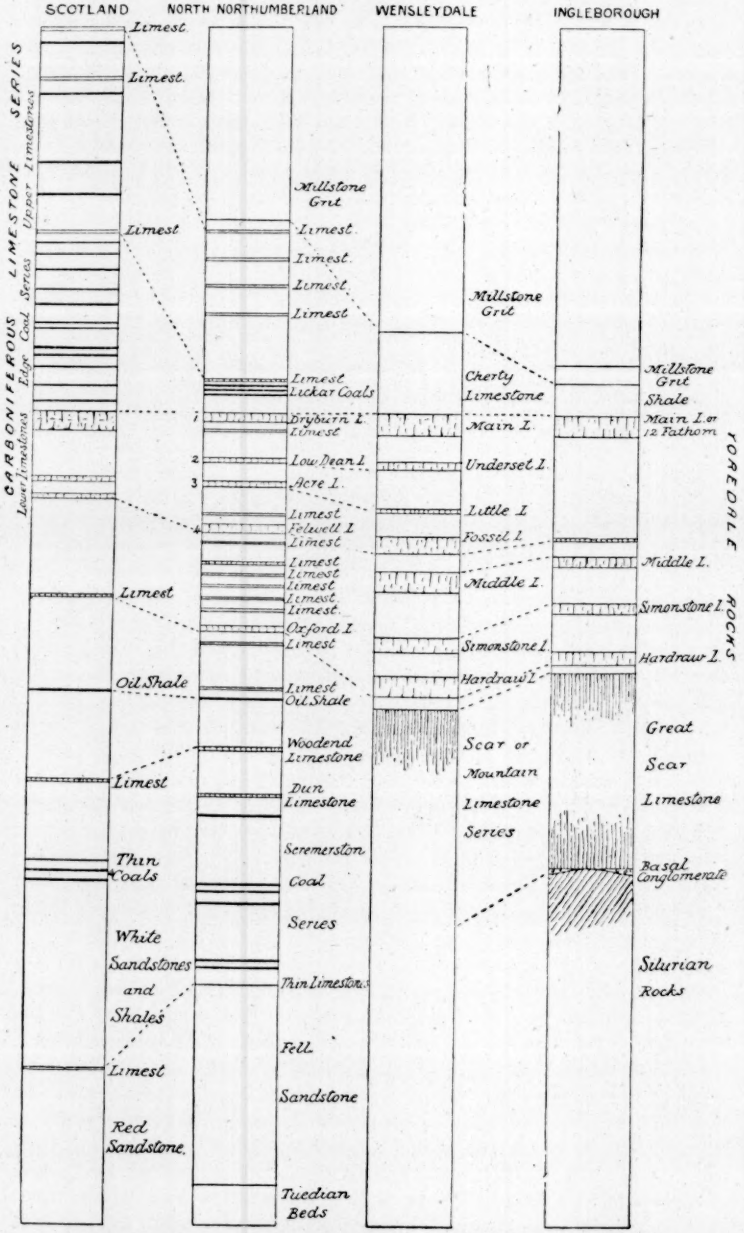
About 12 miles to the north-west, in a direct line from Burnmouth, Lower Carboniferous rocks are found on the coast of Berwickshire,

opposite Cockburnspath. We can recognize here in the white sandstones, interstratified with shales and with several thin and poor seams of coal, the representatives of the Scremerston Coal Series; the group of the Dun and Woodend Limestones is represented by a marine limestone in Cove Harbour, and in the next bay to the westward, immediately under the hamlet of Cove, occurs our well-marked band of oil shale. So far the section on this coast is very clear, but now the rocks which have been dipping steeply north or north-west flatten or undulate, though there seems to be a generally ascending series all along the coast to near Dunbar. Opposite Linkhead, 34 miles from Edinburgh, there is found an impure encrinital limestone, which seems most probably to represent the Oxford. Thus nearly all the lower limestones are dying out one after the other as we proceed westward, and at Skateraw most of the thin limestones between the Oxford and the Eelwell have disappeared, while at Cat Craig the lowest limestone is the Eelwell itself. My colleague Mr. Bennie, who has collected extensively both from the Acre Limestone of Lowick and from the second limestone (counting from below) at Cat Craig, has come independently to the conclusion that these limestones are the same, because they contain a similar assemblage of fossils. As all the rocks below the group of marine limestones at Dunbar have been classed as Calciferous Sandstones, it is now clear that the latter include representatives in time of the lower half of the Yoredale Rocks and the whole of the Mountain Limestone; and possibly the lowest part is older than the Scar Limestone of Ingleborough.

The upper part of the Scottish sectional column, viz. that called Carboniferous Limestone Series, is copied from that given by Mr. Howell on p. 73 of the Survey Memoir on the geology of the neighbourhood of Edinburgh, and it represents the Edge Coals of Midlothian Coalfield. Here we have a great development of coal-seams above the uppermost Yoredale Limestone, and higher up three thin marine limestones also accompanied by coal-seams. We have undoubtedly in Northumberland the equivalents of these upper limestones, also associated with workable coals, which, however, have been omitted from the Northumberland tables; lower down we have, close together, three or four coals which have been worked at Lickar, near Lowick; and elsewhere in Northumberland they are known as Little Limestone Coals. It seems pretty clear, then, that the Edge Coal Series of Midlothian is but an extraordinary development of these Lickar Coals. Even the total thickness of the beds in the Scottish section, some 1,300 feet from the lower limestones up to the Millstone Grit, can be matched in some parts of Northumberland. In Wensleydale this series is represented by a peculiar set of cherts, cherty limestones, etc., which cannot here be described, and on Ingleborough by a mass of shale. The term Yoredale was by the Geological Survey extended so as to include these beds, but they were classed by Phillips with the Millstone Grit, though sometimes he seems to have included a portion of them in his Yoredale Series.

It will thus appear how far from the truth was the old view that

COMPARATIVE SECTIONS OF ENGLISH AND SCOTTISH LOWER CARBONIFEROUS ROCKS.



Corrigendum: for 'Felwell' (in middle of plate) read 'Eelwell.'

the Carboniferous Limestone Series of Scotland represents both the Yoredale Rocks and the Mountain Limestone of England, and that the Calciferous Sandstone is older than the Mountain Limestone. The newer reading, that the Scottish Limestone Series is the equivalent of the Yoredale Beds, and the Calciferous Sandstone of the Mountain Limestone, is a nearer approximation to the truth, but is still far from being correct, especially as it has been shown that the greater part of the Scottish Carboniferous Limestone Series, including the upper limestones and the whole of the Edge Coal Series, lies above the position of the Yoredale Beds of Phillips.

III.—The Solent River.

By the late Sir Joseph Prestwich, M.A., D.C.L., F.R.S.
(Communicated by Lady Prestwich.)

[The idea of a great river flowing through the Solent before the Isle of Wight was separated from Dorsetshire, was very clearly stated in 1862 by the Rev. W. Fox, who for many years was Curate of Brixton, in the Isle of Wight (*Geologist*, vol. v, p. 452). The subject was further dealt with two years later by Sir John Evans (Quart. Journ. Geol. Soc., vol. xx, p. 189), and subsequently by Mr. T. Codrington (ibid., vol. xxvi, pp. 541, 544). Sir John Evans has since entered more fully into the subject ("Ancient Stone Implements, etc., of Great Britain," and *Nature*, vol. xxvi, p. 532); and it was briefly discussed by Sir J. Prestwich in his paper on "The Raised Beaches and 'Head' or Rubble-drift of the South of England: their Relation to the Valley Drifts and to the Glacial Period; and on a late Post-Glacial Submergence" (Quart. Journ. Geol. Soc., vol. xlviii, p. 274).

The following article was marked by Sir J. Prestwich as "part of Submergence paper as first written but reserved for a separate paper."—H. B. W.]

At Portsea Island a change takes place in the character of the drift, the 5 to 6 feet of gravelly clay forming the "Head" on the Old Beach to the east, being replaced on the same level by a bed of gravel, which, according to Mr. T. Codrington, attains a thickness of 27 feet, and still contains some boulders similar to those of Hayling Island, together with blocks of sarsenstone. To the west of Gosport the ground rises and the low cliffs of Stubbington and Hill Head are capped by 10 to 15 feet of gravel of a somewhat different character. No foreign boulders are to be seen in it, though I have found pebbles of quartzite derived apparently from the Triassic strata of Devonshire, as also some small subangular fragments of granite and other old rocks, large blocks of Tertiary Sandstone, and a few worn fragments of a fresh-water limestone[1] containing small *Lymnæ*. There are no shells either fluviatile or marine, and no beach underlies the gravel which rests directly on the Tertiary strata. It is intercalated with seams of sand and loam

[1] Derived from the opposite coast of the Isle of Wight.

roughly bedded, and contains flint implements.[1] It is evident, therefore, that we have here some important changes in physical conditions, and that a considerable alteration in the characters of the drift-beds likewise commences. This has led to the belief that the gravel on the coast from this point to Bournemouth and Poole is the Alluvium of an old river, which, before the removal of the Chalk ridge that extended across the bay of Christchurch, blocked the rivers flowing southward, and diverted them into a main stream flowing eastward, passing along the line of the present Solent and debouching in the area now occupied by Spithead.

I cannot agree in this view, as it is wanting in proof, though as the subject is a complicated one, and would take too much time to discuss at length, I will merely touch upon some of the objections which occur to me. No one can doubt that the Chalk range of the Isle of Wight was once continuous to the Dorset Coast in the Isle of Purbeck, but it does not follow that it formed an impassable barrier by which the drainage of the Frome, the Trent, the Stour, Avon, and other rivers was stayed and made confluent, giving rise to the "Ancient river Solent."

There is no reason why these separate rivers should not have held on their southern course and passed through the barrier as the rivers on the Sussex coast do at the present day. To prove the contrary, it must be shown that the gravel-beds in question are of fluviatile origin, and that they contain the débris of rocks through which the supposed river and its tributaries flowed, also that the levels are such as would accord with the gradients of a river of that character. An able exponent of the hypothesis admits that it is hard to distinguish between the presumed fluviatile gravels and the older probably marine gravels.[2] First, as none of these gravels contain either fresh-water or marine shells, the difficulty is easily understood.[3] By itself this would not be a strong objection, as we all know how frequently such organisms have been removed by the percolation of the surface-waters, but taken in conjunction with others, it cannot be neglected. Secondly, the débris forming the gravel consists almost entirely of materials derived from the high Chalk plateau to the north of the coast-line. Thirdly, there is no maintained fall of the gravel from west to east. The section given by Mr. Codrington[4] along the coast for a distance of 10 miles between Poole and Barton shows the following surface-heights :—West—126, 125, 117, 115, 121, 110, 120, 114, 117, 98, 126, and 114 feet—East; and so on to 95 feet near Lymington. East of Lymington a lower plateau commences, the level of which continues at heights varying from 35 to 40 feet to Hill Head and Stubbington. So much for the surface-levels. Taking the levels at the base of the gravel, the

[1] Evans, Quart. Journ. Geol. Soc., vol. xx, p. 188.

[2] Evans, "Ancient Stone Implements," 1872, p. 609. [See also ed. 2, 1897, pp. 688-696; also "Geology of Isle of Wight," ed. 2, p. 249. Geol. Survey; and C. Reid, "Geology of Bournemouth," 1898, pp. 10, 11, Geol. Survey.]

[3] The only fossil I have found in these gravels is a small indeterminable fragment of bone in a pit near Poole Station.

[4] Quart. Journ. Geol. Soc., vol. xxvi, pl. xxxvii, fig. 2.

result is very similar. The top of the Eocene strata near Bournemouth is from 90 to 115 feet above the sea-level. It is about the same at High Cliff and Barton, and but little less near Lymington.

It is the same with the lower plateau, in which the surface of the Tertiary strata remains on a nearly uniform height above the sea-level for a distance of about 18 miles. Surely it is impossible to suppose that these levels can represent the gradients of a channel such as the supposed river must have had.

From Poole to Lymington, a distance of 20 miles, the gravel is nearly a dead level, and for the whole 35 miles to Stubbington there could only have been a fall of 60 to 70 feet. With these gradients, the transport of such a mass of débris as constitutes the gravel-beds would have been an impossibility; and equally unlikely would have been the sudden ending of the mass at Stubbington, and the escape of Hayling Island from the flood of this supposed river-gravel drift. Nor is the wear of the gravel as it must have been, had it been subjected to this long transport. In fact, there is no difference in the wear between the gravel in the neighbourhood of Bournemouth and that around Lymington—a condition equally inconsistent with the primary assumption.

It is, I think, more probable that the gravels on the Bournemouth and Barton coast represent a vast "head" derived from the high-level gravels further inland, for, like the latter, these coast gravels contain a considerable proportion of chert, ragstone, and ironstone fragments, derived originally from the Lower Greensand, and introduced thus indirectly into these lower-level gravels.

IV.—Further Investigations regarding the Submerged Terraces and River Valleys Bordering the British Isles.[1]

By Professor Edward Hull, LL.D., F.R.S., F.G.S.

I. *Introductory.*—The researches of previous investigators have had the result of showing that the platform on which are planted the British Isles and adjoining parts of the European continent was formerly connected by land with Iceland through the Shetland and Faeröe Islands, and this again with Greenland. This former connection is placed beyond doubt by the character of the fauna and flora. Dr. Wallace includes Iceland in his Palæarctic region, which embraces the British Isles and Europe;[2] and, as Professor Newton has shown, all the land mammalia, with only three exceptions, are European. The exceptions are those of Arctic habitats—the polar bear, the Arctic fox, and a mouse (*Mus Icelandicus*). Amongst the birds, the peculiar species are allied to those of Europe and the Faeröes. The botany and entomology of Iceland have been described in the Transactions of this Institute by the Rev. Dr. Walker, F.L.S.,[3] and his observations bear witness to the former

[1] Read before the Victoria Institute, May 2nd, 1898. Published by permission of the Council of the Victoria Institute. The full paper, with map, will appear in the forthcoming volume of the Transactions for 1897–98.—E. H.

[2] "Geographical Distribution of Animals."

[3] Trans. Vict. Inst., vol. xxiv, p. 205.

land connection of Iceland with the British Isles. He remarks that "the first thing that strikes a visitor from the latter country is not the number of Arctic species, but the great abundance of plants that are very rare and local in Britain, such as *Saxifraga cæspitosa*, *Lichnis alpina*, and *Erigeron alpinum*, etc." The disappearance of the former glacial conditions from the British Isles and their continuance in Iceland account for the remarkable abundance of the plants referred to.

The very ample survey of the insects given by Dr. Walker leads him to the following conclusions :—

1. The total absence of diurnal Lepidoptera.
2. ,, ,, Orthoptera.
3. Neuroptera only represented by Phryganidæ.
4. The most abundant tribes of insects in Iceland are moths and *Diptera*.

On the whole, the insect fauna, as well as the flora, of this island bear a remarkable affinity to those of Scotland.[1]

Now, we must not forget that this community of fauna and flora is characteristic of existing genera and species, and indicates a very recent physical, or land, continuity. It may date back, perhaps, as far as Pliocene times, passing into Recent, but not earlier; and if this be so, we have to consider to what extent the bed of the Atlantic Ocean requires to be raised in order to establish such a land connection, or in other words the amount of recent submergence which it has undergone; we have also to determine the tract of the ocean over which the continuity of land surface formerly existed.

The remarkable results established by American naturalists regarding the submerged terraces and river-valleys adjoining the American continent and prolonged into the North Atlantic, which have already been communicated to the Institute by Mr. Warren Upham,[2] and more recently by myself, have induced me to take up the investigation of the sub-oceanic region adjoining the British Isles with the aid of the Admiralty charts of soundings, which afford most ample materials for such investigation. The results, which appear to me of remarkable interest, I now venture to place before the Institute; from which it will be found that all tend to confirm the view of a very recent elevation of the British, and adjoining continental, areas to the extent of several thousand feet as compared with the level of the ocean surface at the present day.

II. *Land Connection with Iceland.*—An examination of the hydrographical charts shows that it would be necessary to raise the bed of the ocean to the extent of 1,320 feet (220 fathoms) in order to establish a land connection between the British Isles and Iceland. The actual amount of elevation was probably greater and may have reached about 6,000 feet. The evidence for this will be seen further on; and it corresponds very closely with the amount of elevation determined for the coast of North America by the

[1] Supra cit., p. 241.
[2] Trans. Vict. Inst., vol. xxix.

observers already referred to.[1] Indeed, all the evidence obtainable by soundings goes to show that the whole area of the North Atlantic has undergone stupendous changes of level in very recent times both as regards emergence and submergence.

III. *The British Platform.*—The submerged terrace on which the British Isles and adjoining portions of Europe are planted is generally known as "the 100-fathom platform." It is often represented on hydrographical charts, such as those of the late Professor Sir Wyville Thomson, by the 100-fathom contour taken from the Admiralty Chart.[2] But this strict adherence to the 100-fathom contour is misleading as regards the great physical features of the submerged lands; and the same observation applies to the other contours. These features undergo elevation and depression according to geographical position; and it is only by a close observance of the changes of depth, as indicated by the soundings, that the features themselves can be recognized and portrayed.[3]

Throughout a distance of 500 miles from the vicinity of Rockall on the north to the entrance of the Bay of Biscay, the British platform terminates seaward along the margin of a grand escarpment of 7,000 to 8,000 feet in height and remarkable for the steep descent of its flanks; in some cases precipitous. The edge of this escarpment is quite sharp, and well-defined by the sudden descent of the soundings; and at, or towards, its base it gives place to the abyssal plain with a very gentle descent towards the oceanic bottom. Off the coast of Scotland the escarpment is known as the Vidal Bank. Its upper margin very closely coincides with the 100-fathom line, but on tracing the margin southwards it is found to gradually become deeper, till opposite the entrance of the English Channel the margin nearly coincides with the 180–200 contours. The following sections taken at intervals from off the Hebrides to the coast of France, at the entrance to the Bay of Biscay, will illustrate this general statement.[4]

No. 1. Drawn through Rockall to the Isle of Mull, illustrates the form of the sea-bed near the head of the great bay which here penetrates northwards into the plateau, which stretches from Scotland by Rockall towards Iceland, on which the Faeröe Islands and Orkneys are also planted. The margin of the British platform is sharply defined by the 100-fathom contour at about 70 miles from Uinst, at which point the escarpment descends at a steep angle to the 1,000-fathom contour, where it gives place to the abyssal floor of the ocean, descending to a further depth of about 1,350 fathoms or 8,100 feet. The total height of the escarpment is here 7,500 feet approximately.

No. 2. Represents the outline of the sea bed west of County

[1] I have given a short preliminary notice of the results of my examination of the Admiralty charts in *Nature*, March 24th, 1898.

[2] "The Depths of the Sea," pls. ii, iv, v (1873).

[3] The British platform is described by Professor Spencer, GEOLOGICAL MAGAZINE, No. 403, p. 37 (1898).

[4] The sections here described are drawn on the plate which accompanies the original memoir in the Trans. Vict. Inst., vol. xxx, 1898.

Donegal, at Slieve Liag, which rises in a bold headland of nearly 2,000 feet from the ocean. Here the margin of the British platform is still closely represented by the 100–120 fathom contour, and the escarpment descends to the 1,000-fathom line, from which the floor of the ocean gently descends to a depth of about 1,600 fathoms or 9,600 feet; the form and height of the escarpment are similar to those of section vii, but somewhat steeper.

No. 3. This section is remarkable for two points: first, the width of the British platform and the depth of its western margin below the ocean surface. It is drawn from the coast of Clare, where the cliffs of Mohir, formed of Carboniferous Sandstone, rise 400 feet above the sea, along a series of soundings stretching due west for a distance of 280 miles. The platform is here about 200 miles across, and its western margin is indicated by the 200-fathom contour very nearly; that is, twice the depth of the margin opposite Donegal and the Hebrides. The escarpment here, just west of the "Porcupine Bank," is very bold and lofty; descending abruptly from the 200 to the 1,500 contours, being a total descent of about 7,800 feet. Directly north of the Porcupine Bank, the escarpment is quite precipitous, as the two terminal contours (the upper and lower) are in close proximity. With this tremendous descent of over 7,000 feet, the escarpment stretches southward, till opposite the south of Ireland it sweeps round eastward, producing a wide bay about 200 miles across, and sloping upwards to the marginal line of 200 fathoms. Opposite this bay the floor of the ocean descends to a depth of 2,500 fathoms (or 15,000 feet) within a distance of 200 miles.

No. 4. This section is drawn from the coast of Kerry in a south-westerly direction, and is continued eastward over Carantual, the highest mountain in Ireland, reaching a height of 3,400 feet above the sea. The platform is here only 60 miles across, and the descent from its margin is less precipitous than in the case of Sections 2 and 3. The depth of the margin is about 200 fathoms, and after the initial steep descent to about 1,500 fathoms, the ocean bed gently declines, till, at a distance of 170 miles from the margin, it reaches a depth of 2,300 fathoms or 13,800 feet. This is the last of the sections I have drawn, but if another were taken in a south-westerly direction from Ushant, off the coast of France, it would show a platform of 80 miles in breadth, breaking off at the 200-fathom line in a sheer precipice of 5,000 feet just south of La Rochelle Bank, which is situated at the edge of the platform itself.

We have now reached the southern limit of the region which I have proposed to myself for investigation at the northern end of the Bay of Biscay, but I do not doubt that the features here described are continued still further south.[1] From what has been stated it will be seen that throughout a line of coast of 600 or 700

[1] This statement I have since verified by an examination of the Admiralty chart over the Bay of Biscay, which affords most interesting results, especially in the determination of the channels of the rivers Loire and Adour traversing the platform, and descending through deep cañons to the base of the great escarpment.—E. H. (April, 1898).

miles we have a remarkably uniform succession of features, consisting of a gently sloping submerged terrace, stretching out from the coast to a variable distance, but which, on reaching a depth of 100 to 200 fathoms, breaks off in what would be a grand escarpment of 7,000 to 8,000 feet, if viewed from the outer ocean. Such regularity of features through so great a distance cannot be regarded as accidental; it points to uniformity of cause and mode of production. It is to a terrestrial surface we must have recourse for the explanation of the physical conditions here described. We are familiar with examples of plateaux bounded by escarpments leading down into plains both in the British Islands and in other countries. We have a familiar example in the Cotteswold Hills of Gloucester and Somerset; in the range of the Jura; in the range overlooking the Delta of the Nile above Cairo. All these terraced escarpments have been formed over the surface of emergent lands; they are absolutely terrestrial, not oceanic in their origin; and in ascribing a similar origin to those here under consideration, we are only drawing a logical deduction from the premises laid down. In a word, this grand terraced escarpment of the British Isles must have been formed during a period of emergence of the whole region to an extent of several thousand feet above the surface of the ocean, as it is at the present day. Professor James Geikie has recognized the generally abrupt descent of the continental plateau, but does not appear to have recognized that such features must have had a terrestrial origin.[1]

IV. *Submerged River Channels.*—The views I have just expressed receive remarkable confirmation from the existence of old river channels, which may be traced on the Admiralty charts by the soundings. It will be evident that during the period when the British platform was in the condition of a land surface, the rivers descending from the adjoining land, as well as the rain which fell upon its own surface, must have had outlets to the ocean towards the west; and we are, therefore, led to inquire, are such outlets, in the form of river channels, to be recognized by the soundings? I am able to give a very decisive answer in the affirmative to this question. Notwithstanding that the submerged lands around the British Isles have for thousands of years been covered by water, more or less loaded with sediment, and during the later glacial stages laden with icebergs and floes carrying stones and mud, two old river channels, at least, can be clearly traced—one draining the lands now occupied by the waters of the Irish Sea, and the other, by those of the English Channel. The courses of these old rivers are indicated by slightly irregular depressions in the soundings, varying in depth from 2 to 20 fathoms below the general levels adjoining, but they become remarkably accentuated on approaching the margin of the great escarpment, where they are converted into gorges or cañons bounded by precipitous walls of rock, and traceable down nearly to the base of the escarpment.

[1] Address to Geographical Section, Brit. Assoc., 1892: Proc. Roy. Geog. Soc., Sept., 1892, p. 639. The author, however, clearly describes the mode of formation by marine action on emergent lands of such plateaux as the British platform, p. 644.

V. *The English Channel River and the "Hurd Deep."* — The course of the river which drained the area of the English Channel can generally be traced by a curving line of depression from its source near the Straits of Dover to the margin of the great escarpment, where it cuts deeply into the rock in the form of a gorge or cañon. Owing, probably, to silting up by sediment, the course is less evident than it would have been had no sediment been deposited. But at one part of its course its position is still clearly defined on the chart for a distance of 70 miles under the name of the "Hurd Deep." This is a nearly straight E. and W. gorge about 4 to 5 miles across, and at its deepest part 354 feet below the general floor of the sea bed.[1] Here, we may suppose, the channel has been kept open and free from sediment, unlike the portions of the river valley above and below. The cause of this dissimilarity of conditions is not far to seek. On looking at the map it will be seen that the "Hurd Deep" lies in the narrowest part of the channel west of the Straits of Dover, between the Isle of Wight and Portland Bill on the north, and Cape de la Hague and Cape de Barfleur on the south. Above and below this strait the channel broadens out to about twice its breadth between these points; hence the tidal currents have here extraordinary force and swiftness, owing to which the sediment, deposited above and below, appears to have been prevented from settling down and filling up the gorge of the old river. The general outline, the direction and position of this remarkable rift, all point to the "Hurd Deep" as a river channel which has been cut down into the solid rock, and is bounded by steep, or precipitous, cliffs resembling on a small scale the American cañons. The two submarine rivers here described must have exceeded in size any of our existing streams, and we may infer entered the ocean in a succession of grand cascades.[2]

VI. *Comparison with the American Submerged Platform.*—In my former paper[3] I described briefly the results arrived at by Professor Spencer and other American geologists regarding the "drowned" plains, escarpments, and river valleys lying outside the North American coast, and I showed that they consist (1) of the "Continental Shelf," stretching out into the Atlantic as far as the 100-fathom line, or thereabouts, when it breaks off along an escarpment, descending to a depth of 450 or 500 fathoms. This escarpment is then succeeded by a second and more extensive terrace, known as "the Blake Plateau," which in turn terminates along a second grand escarpment descending to the abyssal depths of

[1] The deepest point shown by the soundings is 95 fathoms, while the bordering level of the sea bed is 36 fathoms.

[2] Man was not present to view the scene presented by the British Isles at this time; but we may easily reproduce before our minds its grandeur as visible from the ocean at a distance of a few miles from the coast. In front would rise the lofty terraced cliffs, several thousand feet in height, and stretching away to the north and south in bold headlands and wide bays till lost to sight in the distance; while, planted on the nearly level terrace above, would be seen in the far distance the mountain heights robed in a white mantle of snow.

[3] "On Another Possible Cause of the Glacial Epoch": Trans. Vict. Inst., 1898.

the ocean. It will be observed that as compared with the British subcoastal features there is a general resemblance, but with one important exception, namely, the absence of the representative of the "Blake Plateau." We may, without hesitation, recognize our British platform as the equivalent of the Continental Shelf; but, as I have already shown, the former terminates along the margin of one great escarpment descending to depths of nearly 10,000 feet. A solid escarpment of this kind indicates a slow continuous elevation, after the British platform had been planed down by wave action and subsequent depression after a lapse of time. On the coast of the American continent, however, there appears to have been an intermediate period representing a pause in the process of elevation and subsequent depression, during which the second shelf, or "Blake Plateau," was elaborated.

VII. *Geological Age of the Submerged Features.*—The formation of the British platform, like that of the American "Continental Shelf," may be referred back with confidence to the Mio-Pliocene period, and that of the grand escarpment to the succeeding early Pleistocene or Glacial stage. This view is in harmony with analogy and with what we know of the physical conditions of these periods. The Mio-Pliocene stage was one of great terrestrial changes of land and sea over the European and adjoining areas; but the climatic conditions were warm and genial, with a foretaste of more rigorous conditions towards the close. An elevation of 100 to 200 fathoms round our coasts would have been insufficient to have brought on glacial conditions, although undoubtedly tending in that direction in our more mountainous districts. But a further elevation to the extent of several thousand feet would undoubtedly bring about such conditions; and we are, therefore, justified in inferring a close relationship between this latter rise of the land with the adjoining oceanic bed and the incoming of those Arctic conditions which resulted in covering, not only our mountain heights but also the adjoining plains, with perennial snow and glaciers.

Having already in my former paper treated the subject of the origin of the Glacial period at some length, it is unnecessary that I should dwell upon it here, or explain how the great rise of the land would necessarily result in bringing about glacial conditions in the North Temperate zone, especially when combined with alterations in the temperature of the Gulf Stream. On these points the reader is referred to my former communication, and I shall only add here, that the conclusions which I ventured to enunciate on the basis of the statements of previous authors have been fully verified by my own study of the Admiralty charts, which I have here communicated to the Institute.[1]

[1] Professor T. McK. Hughes, in his interesting paper on "The Evidence of Later Movements of Elevation and Depression in the British Isles," read before the Institute in 1879, postulates a rise of the land to the extent of several thousand feet and infers the climatic changes which would thence result. I hope he will now concur with me that such a rise has actually taken place.—E. H.

NOTICES OF MEMOIRS.

The Geological Survey of Great Britain and Ireland.

Summary of Progress of the Geological Survey for 1897. By Sir A. Geikie, D.Sc., D.C.L., LL.D., F.R.S., F.G.S., Director-General. 8vo; pp. 176. (London: Eyre & Spottiswoode, 1898. Price 1*s.*)

(*Continued from the July Number*, p. 318.)

2. Preparation of Maps, Sections, and Memoirs.—The results obtained by the Geological Survey are made public in three forms: Maps, Sections, Memoirs and Annual Reports, to which may be added the arrangement of specimens in the three national museums, with their diagrams, handbooks, and other explanatory matter, and also the original papers, which, lying often beyond the scope of the Survey's publications, are prepared by members of the staff and, with the consent of the Director-General, are communicated by them to scientific societies and journals.

(*a*) *Maps.*—Experiments were tried some years ago as to the feasibility of producing the one-inch Geological Survey maps by colour-printing. But the scale of these maps is so large, the number of sheets so great, and the sale of many of them so comparatively small, that this method of reproduction has not yet been adopted. A large impression of each sheet would require to be printed off and a considerable stock would accumulate, so that any additions and alterations of the maps would be impracticable for many years. The original system of colouring by hand, which has up to the present time been retained, has this advantage, that by keeping the supply of copies of each sheet just sufficient to meet the demands of the public, any alteration of a map which from time to time may be found to be necessary, can be made without the loss involved in cancelling a large stock of copies.

Colour-printing may eventually be applied to the new series of one-inch maps. In the meantime it has been successfully tried in the case of a general map of England and Wales on the scale of four miles to an inch, to which reference will be made further on.

Some idea may be formed of the nature of the colouring work of the Survey maps, from the fact that upwards of 180 different tints and combinations are employed to denote the various kinds of rocks separately discriminated on them. It is difficult to find colours distinct from each other, yet harmonious, and that will not fade on exposure. To guard as far as possible against the risk of fading, every colour is also distinguished by its own symbol, which is legibly engraved where the colour occurs on the map.

Two editions of the one-inch map of England and Wales are issued for those districts of which the Drift survey has been completed, but where the drift covers small areas one edition is

found to be sufficient. One of these editions shows all the superficial deposits, and only the parts of the underlying formations as lie bare at the surface. The other edition presents the underlying formations as these would appear if the superficial accumulations could be stripped off. Each of these editions has its value for special purposes. In all questions of sanitation, water supply, agriculture, and building, it is obviously the "Drift" edition that should be consulted, while, on the other hand, where the information desired has reference to what lies deeper beneath the surface, as in the sinking of deep wells and mines, it is the "Solid" edition that will be most usually consulted. The difference between the two is merely one of colouring, for they are printed from the same copperplate, and as far as the engraving goes are exact duplicates.

The total number of six-inch maps published by the Geological Survey up to the present time is for England and Wales, 223 sheets; Scotland, 127 sheets; Ireland, 10 sheets. The number of one-inch whole-sheets and quarter-sheets (Old Series) for the whole of England and Wales amounts to 261; 238 of these are published only as "solid" maps; 95 are issued in two editions, "solid" and "drift"; of 23 only the "drift" edition is published. Of maps on the one-inch scale, belonging to the New Series, 15 sheets have been published, 11 of which are issued in two editions with and without drift. The number of sheets published of Scotland is 60, and of Ireland 205. The whole of Ireland has been completed and published. Every effort is now being made to complete at as early a date as possible the survey of Scotland, but the extraordinary complication of the geological structure of the Highlands, being far greater than was ever anticipated, renders the progress less rapid than was originally expected.

The desirability of having a general geological map of the country on a smaller scale than that of one-inch to a mile has long been recognized. When the mapping of England was completed, advantage was taken of the existence of an index Ordnance Survey map on the scale of four miles to an inch ($\frac{1}{253440}$). This map, based on the old one-inch maps, had been laid aside incomplete by the Ordnance Survey, but it was likely to be so useful for geological purposes that at the request of the Director-General it was finished at Southampton. The work of the Geological Survey has been reduced upon this map, of which there are for England and Wales 15 sheets. The whole of these sheets have now been published in chromo-lithography, and when mounted in one sheet present at a glance a clear and vivid picture of the geological structure of the whole country. The price of each sheet is 2*s.* 6*d.*, and the total cost of the map is £1 17*s.*

The value of reduced index-maps for geological purposes was recognized long ago by the preparation of a general map of Wales. When the Geological Survey of the Principality was finished the whole work was reduced to the scale of four miles to an inch and engraved in six sheets, which include parts of the West of England. This map has been on sale for many years.

(*b*) *Sections.*—The Vertical Sections are drawn usually on the scale of 40 feet to an inch, and are prepared almost entirely to illustrate the succession of strata in the coalfields. Each sheet generally contains more than one section. The materials for the plotting of these sections are sometimes obtained by actual measurements taken by the surveyor himself, but more commonly are supplied by the lessees or managers of the collieries. Sometimes tables of comparative sections are given, in illustration of variations in character and thickness between the seams of coal, ironstone, or limestone in different parts of the same mineral field.

Occasionally, where a group of strata, though of little industrial importance, possesses great geological interest, a vertical section of it has been constructed and published in the same style as the coalfield sections. In this way sections of the Jurassic rocks in Eastern Yorkshire, of the Lower Lias and Rhætic rocks in the West of England, of the Tertiary strata in the Isle of Wight, and of the Purbeck group in Dorset have been issued.

Altogether 90 sheets of Vertical Sections have been published for the three kingdoms.

The Horizontal Sections have been an important feature in the work of the Geological Survey. De la Beche, recognizing the practical disadvantages arising from the construction of sections without any regard to the proportion between height and distance, instituted the practice of drawing them on a true scale. He adopted the scale of six inches to a mile, and invented a system of patterns for the different kinds of rock, which, as he was himself an artist, are appropriate and effective, for they represent in no small measure the general structure of the rocks. The institution of such sections, in lieu of the distorted diagrams too generally employed, was of great service to the survey itself and also to the progress of geology; for it served to correct the evil influences of distorted drawing, with regard not only to geological structure but to the true forms of the ground.

As an illustration of the character of these sections and their usefulness in correcting popular misconceptions as to geological structure and the form of the ground, reference may be made to that which runs from Leicestershire to Brighton and passes through London (Sheet 79). What is called the "London Basin" is by many people regarded as a deep trough of clay, with the Chalk rising steeply from under it both to the south and north, and we may see this conception embodied in actual diagrams in textbooks and elsewhere. But in reality both the London Clay and the Chalk are so nearly flat that their inclination can hardly be detected except by careful measurement. And the section, accurately plotted from borings and well-sections, shows them apparently horizontal, though on further inspection we find that their line of junction, which is well above the datum-line at either end, lies several hundred feet beneath it in the centre.

In all, 193 sheets of such sections for the United Kingdom have been issued.

Besides the usual Horizontal Sections on the scale of six inches to a mile, occasional sections on a larger scale are prepared to illustrate the geological structure of particular localities. In this way the coastline of Cromer and Yarmouth has been represented in detail, and its numerous features of geological interest have been inserted so as to exhibit a kind of picture of the arrangement of the strata in these changing cliffs. Portions of the coastline of Dorset and of the Isle of Wight have been similarly treated.

(*c*) *Memoirs.*—It has for some years been customary to insert in the Annual Report of the Director-General of the Geological Survey (submitted to the Science and Art Department, and published in its Annual Report) a general statement of the nature and progress of the operations of the Survey for the year. This statement has at last become too voluminous to find a place in that Report. It is now given in the present publication, which is the first "Summary of Progress." It is intended hereafter to continue this series uniform with the Memoirs.

Obviously, in the course of a geological survey, a large amount of detailed information is collected which cannot find a place either on the Maps or the Sections. This material embraces much local detail, and a large body of evidence which is of importance in general geological inquiry. It can only be properly used by being arranged, condensed, and printed. The issue of Memoirs of its work has, therefore, been from the beginning one of the chief occupations of the Geological Survey of the United Kingdom. The form in which these publications have appeared has varied. De la Beche's plan was to publish volumes of General Memoirs, embracing descriptions of particular regions and also essays on special branches of geological inquiry. His own memoir on the geology of Cornwall, Devon, and West Somerset is an admirable example of his method, and has long taken its place among the classics of English geology. Edward Forbes' striking Essay on the "History of the British Flora and Fauna" and Ramsay's on the "Denudation of Wales" appeared in the first volume of these General Memoirs. There were practical difficulties, however, in the way of continuing these volumes when the staff increased, and the literary labour had to be shared by a number of observers, who were, in many cases, more ready to wield their hammers than their pens. When Murchison succeeded to the charge of the Survey, he sought to avoid these difficulties by instituting the practice of accompanying every sheet or quarter-sheet of the one-inch map with an explanatory pamphlet, giving the chief data on which the map had been constructed, with references to the best sections, lists of minerals, rocks, and fossils, and information as to the geological structure of the ground. These pamphlets, containing essential details only, were to be eventually condensed and collated by the Local Director, so as to form a generalized view of each important geological region. This scheme was well conceived, and with some modifications, rendered necessary by the progress of the Survey, has been continued. It is not always possible or desirable to prepare a separate explanation for each sheet or

quarter-sheet, for much reduplication of geological information would thereby be involved. Several quarter-sheets or sheets may be described together in a single Memoir.

Occasionally these Memoirs, when dealing with an important district, have been expanded beyond the limits of mere Sheet Explanations, and have taken the form of octavo volumes. Such, for instance, are the Memoirs on the Yorkshire Coalfield, on North Wales, on the geology of the Weald, on the geology of London, on the Isle of Wight, and on Cowal, Argyllshire.

The chief literary work on which the staff of the Survey is now engaged is the preparation of the General Memoirs to which the Sheet Explanations were designed to be preparatory. It appeared to the present Director-General that these Memoirs should consist of two series. In the first place, it is desirable that the local details which remain unpublished, or which have been scattered through separate Explanations, should be collected, condensed, and arranged so as to present a description of each important district of the country. As examples of this mode of treatment, the volumes on the Weald, London, and the Isle of Wight may be referred to. In the second place, it is obviously necessary, in the interests of geology, that the contributions made by the Survey to that science should be systematically set forth, and that a full account should be given of each of the geological formations of which the framework of the British Isles is built up. To carry out this requirement a stratigraphical rather than a geographical treatment is needful. A series of Monographs is demanded devoted to the description of the various rock-systems of the country, and brought up to the time of publication by giving not only what has been done by the Survey but an outline of the work of other observers.

The information obtained by the Survey in its progress is necessarily scattered through many maps, sections, and memoirs. The work of the service would be incomplete and difficult of consultation if it were left in this disseminated state. It needs to be gathered together, arranged, and put into connected form, so as to present an intelligible account of the geology and mineral products of these Islands. The task is a heavy one and cannot be speedily finished; but satisfactory progress is being made. A Monograph on the Pliocene deposits of England in one volume, and five volumes of another on the Jurassic rocks, have already been published; one on the Upper Cretaceous rocks is far advanced, and others are in preparation. Each Monograph will embrace one system or group of rocks, and may consist of one or more volumes according to the importance of the system and the area which it occupies in the country.

In the preparation of the memoirs, and for museum purposes, much assistance is now derived from photography. Several members of the staff have become expert photographers, and a large number of views of geological sections, coast-cliffs, and other natural or artificial exposures of rock have been taken. These serve as illustrations for the memoirs, and some of them are mounted to

accompany the specimens in the museums. It is in contemplation also to employ photography for duplication of the six-inch field-maps.

Besides the geological Memoirs, the Survey has published a series of Decades of British organic remains, with plates and descriptions, also Monographs of important genera or groups of fossils, including Professor Huxley's essays on *Pterygotus*, the Belemnitidæ, and the crocodiles of Elgin, and Mr. Newton's memoirs on Cretaceous fishes and Pliocene vertebrates.

3. Petrographical Work.—In the earlier days of the Geological Survey each member of the staff determined for himself, by such tests as he could apply, the various rocks encountered by him in the field. Only in rare cases were chemical analyses made for him. The study of rocks had fallen into neglect in this country, being eclipsed by the greater attraction of the study of fossils. The introduction of the microscope into geological investigation has, however, changed this apathy into active interest. It is now recognized that apart from mere questions of nomenclature, rocks contain materials for the solution of some of the most important problems in physical geology. Accordingly, microscopic inquiry has in recent years been organized as one of the branches of the Geological Survey, and now affords constant and material aid in the progress of the mapping, three members of the staff being specially detailed for petrographical work in the office and in the field. Chemical analyses are likewise made, so as to afford all available information as to the composition of the mineral masses encountered in the field.

The original specimens from which the thin slides have been prepared are kept in cabinets, so that if any accident should befall a slide, a new slice can at once be cut. The mounted slides are arranged in separate cabinets. A large number of such slides has now been accumulated. From Scotland alone nearly 8,000 have been determined, and are ready for reference at any moment.

But besides assisting the field-work, the petrographers are engaged in determinations required for the arrangement of rock-specimens in the museums at Jermyn Street, Edinburgh, and Dublin. The collectors employed under the supervision of the surveying officers to make illustrative series of specimens of the rocks of each district, send these up to the office for examination and for insertion in the museum. In the course of the research thus imposed on them, the petrographers are from time to time enabled to make important original contributions to petrographical science. Moreover, by conferring in the field with the officers who are engaged in mapping, they are enabled to realize the nature of the problems to be dealt with by the surveyor, and the points on which petrographical assistance is needed. Their determinations are embodied in the Memoirs on the geology of the several districts.

4. Palæontological Work.—In a country where the geological formations are to a large extent fossiliferous, it is necessary to pay close attention to the organic remains found in the rocks, to collect specimens of them, to determine these specifically, and to regulate thereby the geological boundary-lines upon the maps. The duty of

examining and reporting upon fossils collected by the Geological Survey is entrusted to the palæontologists, who occasionally visit the field, but are mainly engaged at the museum. With reference to the exigencies of field-work a somewhat similar system is followed with regard to fossil evidence as in the case of the petrography, though the same minute detail is not necessary. The officer, when in doubt about any species, the names of which are needful in separating formations and drawing their mutual boundary-lines, collects specimens of them and sends them up to the office for identification. They are compared by the palæontologist with published descriptions and named specimens, and a list of their specific names (as far as they can be made out) is supplied to the surveyor.

Besides such specimens as may require to be identified in the course of the mapping, full collections from the formations of each important district are made by the collectors under the guidance of the officers by whom the district has been surveyed. Every specimen is numbered and registered in the collector's book, so that its source and destination can at once be found. Lists of the fossils are drawn up by the palæontologists for insertion in the published Memoirs. A selection of the best specimens is placed in the cases, drawers, or cabinets of one or other of the three Museums. Fortunately in the case of the palæontologists also, though much of their work is necessarily of a routine official character, opportunities are afforded to them of making interesting and important additions to palæontological science. It was from this department of the Survey that Edward Forbes produced some of his best work, that Salter made his fame as a palæontologist, and that Professor Huxley enriched geological literature with his memoirs on Silurian Crustacea, Old Red Sandstone fishes, and Triassic reptiles. Within the last few years fresh distinction has been won by Mr. E. T. Newton, of the same department, from the investigation and restoration of a series of remarkable reptiles from the Elgin Sandstones.

5. The Museum of Practical Geology and the Geological Survey Collections in Edinburgh and Dublin.—For the complete illustration of the geology of a country it is necessary not only to construct geological maps and sections, and to publish printed descriptions, but also to collect and exhibit specimens of the minerals, rocks, and organic remains. Each branch of the Geological Survey has from the beginning kept in view the gathering of such specimens, and the galleries of the Museums in London, Edinburgh, and Dublin may be appealed to as evidence of the manner in which the duty has been discharged. The Museum in Jermyn Street is intended to be primarily illustrative of the minerals, rocks, and fossils of England and Wales, but as far as space will admit an endeavour is made to exhibit what is specially characteristic of the other two kingdoms. For more detailed illustrations of Scottish geology recourse must be had to the Museum at Edinburgh, and for those of Irish geology to the Museum at Dublin.

The Museum of Practical Geology, Jermyn Street, as its name denotes, was from the beginning intended to illustrate the applications of geology to the industries and arts of life, as well as the

more systematic treatment of the science. Its materials were meant in the first place to be taken from the United Kingdom and to form a collection in which the minerals, rocks, and fossils of this country should be displayed to the public in connection with examples of their economic uses. The cases of the Museum now contain an extensive collection of the building and ornamental stones of the British Isles, which has been largely made use of by architects, builders, and others. The granites of Cornwall, Devon, Scotland, and Ireland, the marbles of Derbyshire, Staffordshire, Devonshire, Bristol, the Isle of Man, Ireland, and Scotland, are well represented, together with many varieties of serpentine, limestone, dolomite, sandstone, slate, etc. Materials required in the process of grinding and polishing stones, and those illustrating the preparation of plaster and cements, also find a place. One of the most complete parts of the Museum is the great series of specimens illustrating the ores of Great Britain and Ireland. There are likewise colonial and foreign ores, and an important collection illustrating the metallurgy of the metals. Perhaps the most attractive departments of the Museum are the large horseshoe case, in which are placed examples of minerals and their applications in the arts, and the extensive ceramic collection, in which the connection between the raw material and finished pottery is shown. The collection of British pottery was one of the earliest formed, and is still, perhaps, the most illustrative in the country. Models of geologically important districts and of different mines are placed in the model rooms and in different parts of the Museum. The Library contains a tolerably complete representation of the literature of geology, British and foreign, and may be consulted by persons engaged in geological research. Large geological maps are arranged along the lower gallery of the Museum, and can be drawn down and studied by visitors. An extensive and valuable collection of photographs of geological sections and landscapes in the British Isles has been deposited in the Museum and is accessible to students. A microscope and a series of thin slices of typical rocks have been placed in the library for consultation.

The portions of the Museum of Practical Geology most closely connected with the work of the Geological Survey are the collections of fossils, the series of rock-specimens, and the cases illustrating geological processes and rock-structures.

The large series of fossils has been almost entirely obtained from the rocks of the United Kingdom, and chiefly in the course of the prosecution of the Survey. It has furnished the basis on which the maps of the fossiliferous formations have been constructed. Every important subdivision of the Palæozoic, Secondary, and Tertiary systems is represented by a full series of its characteristic fossils, gathered from the various districts in the British Isles wherein it is developed. These are arranged and tableted in such a way as to be readily accessible to the public. Those who wish to follow out the palæontological details of the Survey maps and memoirs, or to study general textbooks of the science, have thus the fullest opportunities afforded to them.

The palæontologists with their assistants are continually engaged in arranging and revising the collections, and in adding fresh material received from the officers in the field, from donations, or from purchase.

The rock-collections have in recent years been greatly increased and entirely rearranged so as to bring them abreast of modern petrography. They include examples of rock-forming minerals, in illustration of the characters of the more important minerals that enter into the composition of rocks; a series of typical rocks, named, classified, and so arranged close to the eye that the visitor may have no difficulty in observing their general external characters; a section devoted to illustrations of various geological structures such as cleavage, jointing, foliation, plication, the structures of igneous rocks, the effects of contact-metamorphism, the markings made by glacier ice, and the results of weathering in different rocks. But the chief part of the collection is a series of British rocks arranged in stratigraphical order from the oldest gneisses up to the most recent shell-sand. Not only are the sedimentary rocks represented in this series, but a large suite of igneous rocks is included, so that the student of volcanic history may see samples of the lavas and tuffs which have been ejected at each of the periods of volcanic activity in the geological annals of Britain. Diagrams and maps are placed near the specimens to show the geology of the districts from which the latter were taken. Drawings are likewise given of the more important microscopic structures met with in rocks, and especially among those of Britain.

A series of handbooks and catalogues has been issued in explanation of the different parts of the Museum. Thus Mr. F. W. Rudler, the Curator, has prepared a general handbook to the whole contents of the building, and also one to the collection of British pottery and porcelain. There are, likewise, catalogues of fossils. A new guide to the rock-collections and another to the palæontological collections are now being prepared.

The Geological Survey collection, illustrative of the geology of Scotland, is arranged in the upper gallery of the west wing of the Museum of Science and Art, Edinburgh. It includes an extensive series of rocks grouped in petrographical order according to the respective counties from which they come, each specimen being traceable to its locality by a pin with its number fixed to the geological maps exhibited in the table-case below. There is, likewise, a large collection of fossils, mainly Scotch, arranged in stratigraphical order. A handbook to the whole collection prepared by Mr. J. G. Goodchild, the Curator, has been published.

The collections of the Irish branch of the Survey deposited in the Science and Art Museum, Dublin, are similarly arranged, and are illustrated by a handbook so full in its descriptions as to serve as a guide to the general geology of Ireland. This useful publication has been prepared by Messrs. A. McHenry and W. W. Watts.

REVIEWS.

I.—Outlines of Vertebrate Palæontology for Students of Zoology. By Arthur Smith Woodward. 8vo; pp. xxiv, 470, with 228 illustrations in the text. (Cambridge: at the University Press, 1898. Price 14*s*.)

THE University Press has added another handsome, well-printed volume to the Cambridge Natural Science Manuals of the Biological Series, and one which cannot fail to attract many readers who are desirous to acquire the broad outlines of this branch of biological inquiry. The subject of Palæontology has now become so large and important that it is no longer possible to include both Vertebrata and Invertebrata within the same cover, nor can any one author be expected to attempt so herculean a task. Owen's Palæontology (1860), one of the earliest, was written by Owen and S. P. Woodward; Nicholson's (1889) is by Nicholson and Lydekker; whilst K. A. von Zittel's Handbuch der Paläontologie has many acknowledged authors of the different sections.

In the present volume we have the veritable *extractum carnis* of many minds, which the Bibliography and the illustrations alike attest, as spiritually present in the work; giving, like the writings of the Fathers, a higher value to the production.

This useful textbook is clearly the direct outcome of Mr. Arthur Smith Woodward's earnest work during the past fifteen years in the British Museum of Natural History, the strongest feature of which, and that possessing also the greatest amount of original research by the author, relates to the Pisces, and to their progenitors, the *Cyclostomi* and *Ostracodermi*, here constituted into a distinct class, the so-called Agnatha, as pertaining to the direct ancestral line in the descent of Fishes. These sections occupy 122 pages of the book, and have no fewer than 80 illustrations after Lankester, Traquair, and the author's own Catalogue of the Fossil Fishes in the British Museum.

The Batrachia, which term is here used to include the whole of the Amphibia, are dealt with in 18 pages with 10 illustrations. The Reptilia occupy 90 pages with 50 illustrations, and the Birds are given 14 pages with 5 illustrations; the three classes having exactly the same number of pages allotted to them as the Fishes and Agnatha. The remaining section is devoted to the Mammalia, which has also the larger proportion of illustrations.

The work concludes with a valuable chapter on the geological succession of the Vertebrate faunas, a copious bibliography, and an excellent index.

Having said so much by way of prelude, we will now invite the author to introduce his subject to the reader.

"The past history of the vertebrated animals, as revealed by fossils, is not merely a subject of absorbing interest in itself; it is also of prime importance in Biology from the possibilities it affords for elucidating some of the most fundamental principles in the evolution of life. Since these organisms represent the highest phase of development to which the animal kingdom has attained,

they appear latest and become dominant latest in the geological series. The evolution of all, except perhaps the larger groups, is thus contemporaneous with the deposition of the series of rocks which yield the most numerous and satisfactory fossils. Moreover, the skeleton of the Vertebrata is more intimately related to the soft parts than that of any of the lower forms of life; hence the greater value of such remains as can be fossilized in determining the precise nature of the original animals to which they belonged."

"The order in which the various divisions of the Vertebrata appear in geological time, according to present knowledge, depends entirely upon their degree of specialization—the simplest first, the more complex afterwards. The earliest organisms, which seem to have possessed a notochord, occur in the Upper Silurian; and none of these ancient types hitherto discovered exhibit either a lower jaw or true paired limbs. Typical fishes appear first in the passage beds between the Upper Silurian and Lower Devonian, and become abundant in the latter formation. Batrachia begin to occur in the Lower Carboniferous, and are dominant in the Permian. Undoubted reptiles are found in the Lower Permian, but do not become dominant until the Triassic and Jurassic. Fragments either of mammals or of reptiles, which approach the latter extremely closely, are met with in the Triassic, and there are undoubted small mammals in the Jurassic; but these are insignificant before the Tertiary period. Birds occur first in the Upper Jurassic, but both on this horizon and in the Cretaceous they retain conspicuous characters of their ancestry which have subsequently disappeared; they seem to have become dominant contemporaneously with the mammals at the beginning of the Tertiary period.

"*Range in Time.*—Gradual evolution—whether in the form of progression, retrogression, or differentiation—is usually observable, even in the minor divisions, when their range can be traced through the geological formations; and characters change more or less slowly in proportion to their magnitude. In all satisfactorily known instances, an order exhibits a longer geological range than any of its contained families; its family-types persist for a longer time than any of the genera grouped under them; whilst the genera themselves remain for a more extended period than the species. A highly specialized member of any division is also more liable to early extinction than its more generalized congeners, probably from its less adaptability to changes in the environment. An illustrative case may be cited. The order Ungulata (hoofed-mammals) is known to range from the very earliest Eocene strata to the present day. The family Equidæ (horses), as commonly understood, arises in the Upper Miocene; the typical species of the surviving genus *Equus* appears first in the Lower Pliocene. One genus of this family (*Hipparion*), with highly complex teeth, was restricted in its range to the Upper Miocene and Lower Pliocene periods, while another (*Hippidium*), with much specialized nasal region, had only a brief existence in South America; whereas *Equus* itself, with more normal teeth and rostrum, has survived from the Lower

Pliocene to the present day. In like manner the highly specialized rhinoceros, *Elasmotherium* (Pleistocene of Russia), had a very limited range in time and space compared with its more ordinary allies.

"*Persistent Types.*—There are a few noteworthy exceptions to the common rule last mentioned, which still await explanation. These are generally referred to as 'persistent types.' There is one remarkable, highly specialized family of Crossopterygian fishes, the Cœlacanthidæ, ranging from the base of the Carboniferous to the top of the Cretaceous, with scarcely any modification which can be regarded even as denoting change in the genera representing it (see p. 78). The case of the Tapirs, ranging practically unaltered from the early Miocene to the present day, is also a striking illustration (p. 321).

"*Imperfection of the Geological Record.*—The difficulties in ascertaining and interpreting the facts of Palæontology are, of course, greatly enhanced by the imperfection of the geological record on which we depend. Every item of knowledge acquired may indeed be literally described as owing to a chapter of accidents. Firstly, the organism must find its way into water where sediment is being deposited, and there escape all the dangers of being eaten; or it must be accidentally entombed in blown sand or a volcanic accumulation on land. Secondly, this sediment, if it eventually happens to enter into the composition of a land area, must escape the all-prevalent denudation (or destruction and removal by atmospheric and aqueous agencies) continually in progress. Thirdly, the skeleton of the buried organism must resist the solvent action of any waters which may percolate through the rock. Lastly, man must accidentally excavate at the precise spot where entombment took place, and someone must be at hand capable of appreciating the fossil and preserving it for study when discovered. Having due regard to the doctrine of Chances, the palæontologist will thus not be surprised to learn, for example, that the Lower Devonian chordate animal *Palæospondylus*, the unique representative of its group at present known, has hitherto been found only in one stratum of flagstone a few inches thick in one quarry in Caithness (see p. 3); that *Archæopteryx*, perhaps the most precious of Jurassic vertebrates, is known only by two specimens and a feather from the Lithographic Stone quarries of Bavaria, which have been worked from time immemorial (see p. 232); and that the sole known evidence of a Pleistocene monkey in Britain is a detached molar tooth from one of the brickfields near Grays, Essex. Furthermore, it must be remembered that in every region the series of strata contains only a very discontinuous record of its successive faunas and floras. When a region is a land area, as a rule, no deposit capable of preservation for long periods can accumulate, and the characters of its life can only be inferred from fossils which have been entombed in sediments apparently of the period in question elsewhere. When the region happens to be covered with comparatively deep water, the sediments will contain scarcely any but aquatic organisms, rarely yielding a trace of the life on the nearest land.

"*Definite Direction of Evolution.*—Under such circumstances it can be readily understood, that the time has not yet arrived for deducing general laws from the data of Palæontology. In fact, our knowledge of the evolution even of the Vertebrata is most casual and fragmentary in character. Nevertheless, sufficient is known to indicate that changes in the vertebrate skeleton have taken place in a certain definite and irreversible order; and the relative age of two skeletons of the same type of animal of widely different periods can readily be determined at a glance by an expert. For example, among the early Palæozoic fishes there are many heavily-armoured forms with very little ossification in the endoskeleton and only incipient vertebral centra. The endoskeleton does not begin to ossify to any noteworthy extent until the exoskeleton atrophies; eventually at a later period the bony endoskeleton is the all-important part of the framework. Now, it so happens that in certain Mesozoic Pycnodont fishes (*Mesturus*) and the Tertiary coffer-fishes (Ostraciontidæ) the rigid dermal armour is again acquired; but it is apparently contrary to law for the endoskeleton to revert to its primitive state, as observed in the Palæozoic fishes just mentioned; the parts of the axial skeleton simply become rigidly fixed, and are nearly as well ossified as in their unarmoured contemporaries and relatives. When the vertebral centra have once become fully formed, indeed, they never degenerate to allow the unconstricted notochord to persist again. To take another example, the lobate fins with endoskeletal supports in the earliest fishes always appear to tend towards atrophy, while the dermal rays surrounding them become stouter; and when the endoskeletal base of the fin has been reduced to one small row of elements, these never multiply again; even the lobe of the great pectoral fin of the modern angler-fish (*Lophius*) is formed solely by the elongation of two of these little elements. The same phenomenon is observed among mammals; the number of digits may be reduced even to one, but when any reduction has taken place the original pentadactylism is never restored. Finally, in the case of all vertebrates, the teeth tend to degenerate; first the supply of successional teeth is stopped, then the one 'permanent' set disappears: and when either of these phases of degeneration is accomplished, the original state is never recovered.

"*Specialization.*—It is thus evident that among animals there are certain definite and irreversible lines of progression, and other equally definite and irreversible lines of degeneration. At the same time the Palæontology of the Vertebrata shows most clearly that, on the whole, the evolution of these organisms has proceeded from the general to the special, while in every successive period of the earth's history some group has risen to a higher position in the zoological scale than any previously attained.

"*Expression Points.*—All known facts appear to suggest that the processes of evolution have not operated in a gradual and uniform manner, but that there has been a certain amount of rhythm in the course. A dominant old race at the beginning of its greatest vigour seems to give origin to a new type showing some fundamental

change; this advanced form then seems to be driven from all the areas where the dominant ancestral race reigns supreme, and evolution in the latter becomes comparatively insignificant. Meanwhile the banished type has acquired great developmental energy, and finally it spreads over every habitable region, replacing the effete race which originally produced it. Another 'expression point' (to use Cope's apt term) is thus reached, and the phenomenon is repeated. The Actinopterygian fishes furnish an interesting illustration. The earliest known member of this order (*Cheirolepis*) appears as an insignificant item in the Lower Devonian fauna, where Crossopterygian and Dipnoan fishes are dominant. When the latter begin to decline in the Lower Carboniferous, the suborder to which *Cheirolepis* belongs (Chondrostei) suddenly appears in overwhelming variety. By the period of the Upper Permian another fundamental advance has taken place—the Protospondyli have arisen; but only a solitary genus is observed among the hosts of the dominant race. In the Trias the new type becomes supreme, and at the same time the next higher suborder, that of the Isospondyli, begins to appear. This lingers on in the midst of the dominant Protospondyli during the Jurassic period, and then in the Cretaceous this and still higher suborders suddenly replace the earlier types and inaugurate a race which has subsequently changed only to an insignificant extent. The Mammalia afford another illustration of the same phenomenon. The reptilian class shows the closest approximation to that of the Mammalia at the dawn of the Mesozoic epoch, when it is just beginning to replace the older Batrachia. In rocks of this age, on all four continents—Europe, Asia, Africa, and America—there are numerous remains of the mammal-like Anomodontia (as they are termed, p. 144). Afterwards not a trace of these 'missing links' is known; and with the exception of the insignificant small jaws of possible Prototheria and Metatheria in the Jurassic and Cretaceous of England and North America, mammals do not appear either in Europe, Africa, or North or South America until the base of the Eocene, when they suddenly became dominant and are already differentiated.

"*Parallelism in Evolution.*—As nothing is yet known of the supposed refuges to which the incipient new races have betaken themselves to differentiate and acquire vital energy, we can merely assume them as a tentative hypothesis. But even when the facts are abundantly manifest, it is often difficult to settle the most elementary questions by direct reference to them. The problem of parallelism in evolution is one of these. It is necessary to determine whether the same animal can be evolved simultaneously in more than one region from distinct series of ancestors. Are the pumas and jaguars of America, for example, wandering cousins of the lions and leopards of the Old World, or have they been evolved on the other side of the globe through a distinct set of carnivorous ancestors? The case of the horses is often cited as suggesting that such a parallelism in evolution may have occurred; because the series of ancestral horses traced through the Tertiary strata of Europe is

closely similar to, but not quite identical with, the ancestral series found in the same order in the corresponding rocks of North America. Here the facts are tolerably well known, but they admit of more than one interpretation. An easy land-connection between Europe and North America, throughout the Tertiary period, if allowed by geological considerations, might account for the phenomena observed, even if all the horse-like animals were evolved from one stock in one and the same area.

"*Theory of Recapitulation.*—There is also the well-known and widely-accepted principle that the stages in the development of an individual organism at the present day repeat in a general manner the successive phases through which the ancestors of that organism have passed in former periods of the earth's history. There is no doubt, for example, that in the course of its individual development the homocercal tail of a modern bony fish passes through the same stages as those successively exhibited by the majority of the adult fishes at the different geological epochs. It is also evident that the family of deer (Cervidæ) has gradually acquired complex antlers in precisely the same manner as every modern stag acquires them during the course of its individual life. Again, the 'cloven foot' of the existing ruminant appears in the embryo with separated metapodial bones, like those of the adult ancestral ruminants. It is also tolerably certain (though fossils have not yet provided absolute demonstration) that the rudimentary teeth and hind limbs of the existing whalebone whales (Mystacoceti) are inherited from functionally toothed quadrupedal ancestors. Embryology, however, cannot afford much precise information concerning these processes of evolution, because an embryo usually exists under physiological conditions totally distinct from those influencing an adult. The embryo exhibits features derived from its ancestors (*palingenetic* characters), inextricably mingled with features due to the peculiar circumstances under which it develops (*cænogenetic* characters). In most cases it has hitherto been impossible to distinguish these two sets of characters satisfactorily; and a final appeal must thus be made to Palæontology, notwithstanding its imperfections, to determine the laws by which evolution proceeds.

"*Origin of the Vertebrata.*—Perhaps the most disappointing element in palæontological results thus far, is the lack of all information concerning the origin of the great sub-kingdoms or phyla of animals. Even in what might appear to be the most promising case, namely, that of the Vertebrata, there are no known facts distinctly favouring any of the rival theories concerning their origin based on embryology. Possibly all the earliest types were destitute of hard parts, and thus incapable of fossilization. In any case, the oldest Ostracoderms (p. 3) from the Upper Silurian and Lower Devonian, sometimes claimed as the immediate allies of the Crustacean or Arachnid Merostomata of the same period, are fundamentally different from the latter in every character which admits of detailed comparison; they are to be regarded merely as an interesting example of mimetic resemblance between organisms of two different grades, adapted to live in the same way and under precisely similar conditions."

As this volume is designed for the use of students, it may not be improper to suggest that in every case where *new terms* are introduced a gloss should be given explanatory of such terms.

Again, it is hardly consistent to place *Tritylodon* (p. 154, fig. 97) with the Theriodonts, as a matter of course, if it has (as the author admits) been commonly ascribed to the Mammalia by Owen and others who have written upon the subject; whilst *Polymastodon* (p. 253, fig. 149 B), with precisely similar multituberculate molars and similar number of incisors, remains unchallenged and is admitted as one of the Prototheria.

And why should "other double-rooted multituberculate teeth from the Rhætic of Europe, commonly claimed as mammalian" (p. 248), be suspected of being Anomodonts in disguise?

The illustrations of amphibian and reptilian skulls, and of mammalian teeth, have in some instances been borrowed from authors whose views as to their interpretation are not quite the same; as a consequence we have the nomenclature given in one illustration at variance with that given in another. In one case, for instance, on p. 143, fig. 91, the squamosal and supratemporal change places in figures B and E.

In fig. 183, p. 323, the cheek-teeth of *Hyracotherium* (after Wortman); fig. 185, of *Palæotherium* (after Gaudry); fig. 187, *Mesohippus* (after Osborn); and fig. 189 (after Earle), the references do not always agree; the cones being differently lettered. In the fourth premolar Gaudry's *paracone* E is equal to the protocone in the other figures.

One is inclined to question the advisability of the adoption of the terms *Asterospondyli* and *Tectospondyli*, in place of the time-honoured and well-known SELACHOIDEA and BATOIDEA, especially as these terms are based upon the minute structure of the vertebræ (radiations being more pronounced in one and concentric layers in the other), structures which are not easily to be made out, and whose absolute constancy one might be inclined to doubt.

There is a good table of geological periods given, facing p. 411; but in the blank part folded for drawing out the table, there is ample space afforded to have given four columns for the leading groups of Fishes, Reptiles, Birds, and Mammals, briefly summarized, which might have proved exceedingly useful to the palæontologist.

On the whole, we like the book very much, and consider it distinctly in advance of any similar effort in Vertebrate Palæontology.

The geographico-geological chapter at the end is useful, and contains much good matter. Why, we may ask, should the Protospondyli of the Jurassic be spoken of as the *dominant race of vertebrate life*? One would suppose the Sauropterygia and the Ichthyopterygia were the dominant aquatic races of vertebrate life, and the Dinosauria the terrestrial reigning type.

But let the work stand upon its own feet; we have commended it, and we will stand by our word. Those who desire a good book on Vertebrate Palæontology will certainly do well to procure a copy for their reference library.

II.—The Extinct Rhinoceroses. By Henry Fairfield Osborn. Mem. Amer. Mus. Nat. Hist., vol. i, pt. 3 (1898), pp. 75–164, pls. xii*a*–xx.

SINCE the appointment of Professor Osborn as Curator of Vertebrate Palæontology in 1892, the American Museum of Natural History has published some of the most remarkable contributions to our knowledge of the Tertiary Mammalia which have yet reached us from the New World. Year after year expeditions have been sent to the West to make systematic geological explorations, and to collect fossils in the Tertiary lake-deposits, which began to yield their startling novelties to Leidy in the early fifties. The collections have been prepared, and the best specimens mounted, under the direction of a skilled preparator, Mr. Hermann. Preliminary studies have then been made by Professor Osborn, Dr. Wortman, Dr. W. D. Matthew, and Mr. Hatcher; and the results have been published in a series of "Bulletins," illustrated by the well-known careful drawings of Mr. Rudolf Weber.

A still more important departure has now been made, in the issue of the first two sections of an exhaustive quarto memoir on the extinct rhinoceroses by Professor Osborn himself. This is illustrated, not only by diagrams and the usual text-figures of fossils, but also by nine lithographed plates; and the plan of the work is not confined to a bare record of the facts, but also comprises a discussion of some of the most fundamental problems in the philosophy of Palæontology. We commend the memoir both to the notice of the specialist in the study of mammals, and to the general reader who desires to become acquainted with the latest-discovered facts bearing upon the phenomena of organic evolution.

Professor Osborn first discusses the differentiation of the Hyracodonts, Amynodonts, and true Rhinoceroses. These, he remarks, may be popularly described respectively as the Cursorial or Upland Rhinoceroses, the Aquatic Rhinoceroses, and the True or Lowland Rhinoceroses. To the first family belong agile, three-toed genera (such as *Hyracodon*), simulating the Miocene horses in skeletal structure and in the development of true hoofs. To the second family are referred short, heavy animals, with four-toed spreading feet, enlarged canine teeth, and probably a prehensile lip or proboscis (such as *Metamynodon*). The third family comprises rhinoceroses much like those still surviving in the Old World, the extinct American forms only differing from the latter in the non-development of the nasal horn. These families were all differentiated, at least in the North American area, before the middle portion of the Eocene period; and as they are traced upwards in time, they exhibit a curiously parallel course in the evolution of the molar teeth, while in the characters of the incisor teeth, skull, vertebræ, and limbs they rapidly become more and more divergent. Professor Osborn describes this parallelism and divergence in detail and adds much to the value of his memoir by giving concise tabular summaries of his results. It is indeed strange that we should thus

receive the most important and fundamental information concerning the ancestry and evolution of the rhinoceroses from the Tertiary formations of the New World, where no one, prior to the discoveries of 1850, could ever have suspected the occurrence of so characteristic an Old World type of mammalian life.

In the second chapter of the memoir, Professor Osborn deals with the true rhinoceroses, and begins with a useful synopsis of the existing species of the Old World, illustrated by a series of drawings of the skulls. Next, he gives a brief historical statement of the discovery of the extinct rhinoceroses, both in Europe and North America. Finally, he discusses the characters of the skull and teeth in formulating a basis of classification to be adopted in the technical account of the extinct rhinoceroses which follows. There is also a "preliminary bibliography."

Of the technical part of the memoir only the first section is now published, namely, a description of the cranial and dental characters of the hornless rhinoceroses ("Aceratheres") from the American Oligocene, or White River Beds, of which a stratigraphical table is inserted. Seven species of *Aceratherium* are successively treated; and the so-called *A. trigonodum* is placed in a new genus, *Leptaceratherium*, on account of the persistence of its upper canines. Two important immature skulls with the complete milk-dentition are referred to *A. occidentale*.

The forthcoming sections of this memoir are announced to deal, not only with the remaining American forms, but also with those of the Old World. We understand that Professor Osborn is at present enjoying a year's leave of absence from his professorial and curatorial duties, and is thus favoured with the opportunity of continuing his extensive studies of the European collections. We await the result, so far as our knowledge of the extinct rhinoceroses is concerned, with great interest and high expectations.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—June 22, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "Post-Glacial Beds exposed in the Cutting of the new Bruges Canal." By T. Mellard Reade, C.E., F.G.S.

The following beds, enumerated in descending order, were found in this cutting:—

5. Argile des polders supérieure.
4. *Cardium* (*edule*)-sand.
3. Argile des polders inférieure.
2. *Scrobicularia* (*plana*)-clay.
1. Peat with the remains of trees.

Mechanical analyses of beds 5 and 2 are given. The argile des polders supérieure consists mainly of extremely finely divided material, in which sponge-spicules and foraminifera were found.

The *Cardium*-sand yielded many foraminifera and ostracoda, with a few diatoms. The *Scrobicularia*-clay contained sponge-spicules, many of them apparently derived from older deposits, diatoms, and foraminifera.

The land-surface on which the peat grew appears to have slowly subsided, in such a manner as to allow of the inosculation of beds 1 and 2 at their junction. Beds 3 and 5 represent the shallower-water phases, and the *Cardium*-sand the deepest-water phase through which the area passed as the deposits accumulated. As a whole, these beds are correlated with those "in Lancashire and Cheshire which overlie the Peat and Forest Bed," but the wide horizontal extent of the deposits, at levels varying very little, has no parallel in Britain.

2. "High-level Marine Drift at Colwyn Bay." By T. Mellard Reade, C.E., F.G.S.

This paper describes a mound of sand capped by Boulder-clay, which occurs one mile south by west of Colwyn Bay Station. It measures about 90 yards on the longer axis, which runs north-east, 50 yards on the shorter axis, and is situated 560 feet above O.D. Among the pebbles and boulders in the drift, and scattered about in the sandpit, were granites from Eskdale and the South of Scotland, small flints, and local and Welsh rocks identified by Mr. Ruddy as derived largely from the head of the Conway Valley. The base of the sand is not exposed, but the author has no doubt that it is geologically above the grey till with Welsh boulders.

At Groes and Old Colwyn a "typical marine-drift sand," with well-rounded quartz-grains, also occurs, at one place possibly 60 feet thick, and at another resting on "marine brown boulder-clay." The marine sands of Groes, Old Colwyn, and the Vale of Clwyd "lie on the east side of their respective valleys, and the marine boulder-clays to the greater extent on the west side," while the marine drift has accumulated as bars near the mouth of the valleys.

3. "Observations on the Geology of Franz Josef Land." By Dr. Reginald Kœttlitz. (Communicated by E. T. Newton, F.R.S., F.G.S.)

This paper opens with a detailed description of the geography and geology of various portions of the archipelago.

The basaltic rocks occur in tiers from 10 to 70 feet high, and range to a height of 1,300 feet above sea-level. The associated and interbedded rocks consist of shale, sandstone, and basaltic tuff. The stratified rocks are not appreciably altered by the heat of the basalt, which is often vesicular both at the base and summit of the tiers. From this and other evidence the author concludes that many of the sheets are contemporaneous flows, and that as the fossil plants and ammonites are of Jurassic age, some of the lavas date back to Jurassic time. Dykes, sills, and necks are also described.

The Jurassic rocks consist of shales and sandstones; they have yielded ammonites and belemnites, a portion of a specimen of *A. Lamberti* having been found embedded in "basaltic tuff." Pebbles

of radiolarian chert have also been found embedded in these rocks, and a granite-block, mentioned by Payer as having been seen embedded in an iceberg, is believed to have come from the same source.

The raised beaches are very numerous, and occur at various heights, from just above sea-level to 287, 310, 340, and even 410 feet, drift-wood and bones of seals, walrus, and whales having been found on them. On Cape Mary Harmsworth twelve beaches are seen in a series one above another. The entire skeleton of a seal was found on the summit-plateau of Cape Neale, together with waterworn stones, at a height of 700 feet above sea-level. The highest waterworn pebbles noted were found at 1,111 feet on Cape Flora. In some cases floe-ice at sea-level becomes covered over and preserved by gravel heaped upon it by the sea; and some of the raised beaches seem to consist of a similar mixture of ice and gravel, as is proved by the formation of pitfalls in them where the ice melts. Ice-masses are also sometimes preserved under taluses, avalanches, and slips.

The "ice-cap" is probably not so thick as is generally supposed, and it has little downward movement. It forms domes on the summits and plateaux, but it seems to be a mere mantle on the terraced slopes, as it is ridged and dimpled, and during warm seasons raised beaches and terraces are thawed out under the ridges. Comparatively few evidences of glaciation were met with. Roches moutonnées and rounded hills are absent, and only in the two valleys separating Cape Flora from Cape Gertrude were the rocks planed, scratched, and polished.

Some of the landscape features, including the separation of the group into individual islands, are attributed to marine action following lines of fault.

The paper concludes with observations on soundings, the temperature of glaciers, the size of icebergs, and the finding of reindeer-antlers by Mr. Leigh Smith and the members of the Jackson-Harmsworth Expedition.

4. "Notes on Rocks and Fossils from Franz Josef Land brought home by Dr. Kœttlitz, of the Jackson-Harmsworth Expedition, in 1897." By E. T. Newton, F.R.S., F.G.S., and J. J. H. Teall, M.A., F.R.S., V.P.G.S.

In this communication an analysis of the basalt is given, which compares closely with those of basalts from Iceland. The silicification of the rocks, presumably by geyser action, the presence of a black analcime, pebbles of radiolarian chert, and crystals of selenite, probably formed *in situ* in shale, are also described.

Notes are given on some of the fossil plants, on the drift-wood, and on apparently new species of *Inoceramus* and *Belemnites*.

5. "On the Corallian Rocks of Upware." By C. B. Wedd, B.A. (Communicated by J. E. Marr, M.A., F.R.S., F.G.S.)

The opinion usually held that the "Coralline Oolite" of the northern quarry at Upware is of older date than the "Coral Rag"

of the southern quarry, gains support from the work detailed in this paper, although the results of recent excavations show that a rock of different lithological character from that of the northern quarry probably underlies the rocks of the southern quarry.

A list of the fossils found in the lowest beds of the southern quarry includes eleven species not yet found in the "Oolite" of the northern quarry; a second list comprises the fossils found just below the "Rag" in the Oolite of the southern quarry. Both these faunas are intermediate between those of the "Rag" of the southern and the "Oolite" of the northern quarry.

During the deepening of a well less than a quarter-mile north of the northern quarry, fossils identical with those of the northern quarry were found; the lowest rock enclosed lumps and streaks of bluish-black clay, as though the Oxford Clay were not far underneath. From this excavation and other evidence, the author considers that the "Oolite" can hardly be less than 40 feet thick, and that this rock is geologically below the "Rag" of the southern quarry.

Excavations at the southern end of the ridge and south of the southern quarry show that beds containing the "Rag" fauna are conformably underlain by a rock 16 feet thick, identical with the "Elsworth Rock" both in lithology and fossils. The discussion of the fossils from this rock and that of Elsworth itself indicates that "there is no longer any palæontological evidence for correlating it with the Lower Calcareous Grit rather than with higher beds."

On the whole, the author is in favour of the view that the "Oolite" of the northern quarry is the lateral equivalent of the Elsworth Rock seen in the excavations south of the southern quarry.

The next meeting of the Society will be held on Wednesday, November 9, 1898.

CORRESPONDENCE.

"THE LLANBERIS UNCONFORMITY."

Sir,—The letter from the Rev. J. F. Blake which appears in your issue of July, p. 335, seems to call for a short comment from me. The paper by Professor Bonney and myself published in the Q.J.G.S. for 1894 was founded on the work done in Wales by both authors. Previous to my investigations, the work of Professor Bonney had led him to conclusions mainly identical, I believe, with those which we enunciated. He had visited the district after the publication of his earlier paper;[1] and he re-examined in 1893 the critical sections in both the Bangor and the Llanberis area. His opinion on the question of the 'unconformity' which has been claimed as exhibited along the L. Padarn railway, was drawn from his own examination of the section. Of the sections not examined by him, the only important one, I believe, is that at Bryn Efail, and of those rocks he saw all my specimens. But his scrupulous sense of justice

[1] I believe this was in 1880; I am not sure of the exact year.

demanded that he should give away the credit for the "larger share of the work." I did not anticipate, when I saw the note appended by him to our joint paper, that it could be misinterpreted to mean that, because Professor Bonney had not seen or re-examined certain sections (many of them supplementary), therefore he had not seen sufficient to draw his own conclusions. To those who know his work this statement must seem unnecessary.

CATHERINE A. RAISIN.

ON A QUARTZITE AND SYENITE ROCK IN WORCESTERSHIRE.

SIR,—The valuable note by Mr. Charles St. Arnaud Coles in your July number (p. 304) suggests several questions of interest to students of Malvernian geology. I can quite confirm his descriptions in a general way, as I have visited Martley, and collected specimens of the rocks. The so-called syenite is an altered form of one of the Malvern diorites, the biotite and quartz being of secondary origin; but, as the modifications undergone by these diorites have been described in my series of papers on the Malvern Hills (Quart. Journ. Geol. Soc., August, 1887, August, 1889, and August, 1893), I need not here discuss them. The chief point of interest is the relation of the quartzite to the Malvernian. Mr. Coles compares the former with the quartzite of the Lickey. He might with equal probability have included in his correlation the basal Cambrian quartzite which clings like a blanket round the Malvernian and Uriconian masses of Shropshire. Whether this quartzite occurs in the Malvern chain I cannot say from personal knowledge; but, in the well-known section at the southern end of the Raggedstone Hill, the Hollybush Sandstone is thrust over the upturned edges of the contorted gneiss, and the quartzite is wanting, its absence being probably due to dislocation.

C. CALLAWAY.

July 15, 1898.

OBITUARY.

PROFESSOR GEORG BAUR, PH.D.

BORN JANUARY 4, 1859. DIED JUNE 25, 1898.

WE deeply regret to record the death of Dr. Georg Baur, of the University of Chicago, at the early age of 39 years. He was born at Weisswasser, in Bohemia, where his father was at the time Professor of Mathematics; but he spent the greater part of his youth in Hesse and Würtemberg. He passed through the Gymnasium at Stuttgart, and in 1878 entered the University of Munich, where he devoted special attention to zoology, palæontology, geology, and mineralogy. In 1880 he went to Leipzig, where he studied under Credner and Leuckart. Two years later he returned to Munich and took the degree of Ph.D. He remained at this University as assistant to Prof. von Kupffer until 1884, when he left for America and became assistant to Professor Marsh at Yale. Dr. Baur held this appointment until 1890, when he removed to the Clark University,

Worcester, Mass. Two years later he was appointed to be Assistant Professor of Comparative Osteology and Palæontology in the newly-founded University of Chicago, and in 1895 he became Associate Professor — the position he held at the time of his death. Last autumn his health began to fail, on account of excessive mental strain. He then came to Europe to spend a holiday with his relatives in Germany; but his mental powers were never recovered, and the disease rapidly culminated in death.

Dr. Baur was a vertebrate morphologist of the modern school, who looked as much towards extinct animals as towards the existing fauna for the basis of his researches. He thus added greatly to our knowledge of vertebrate palæontology, not so much in describing new types, as in formulating new and clearer conceptions of forms already named and made known by other workers. His contributions, though mostly very brief, have had considerable influence upon the classification of the Reptilia now most widely adopted; and some of his papers contain important new facts concerning the skeleton of the Ichthyosauria, Chelonia, and Mosasauria.

Dr. Baur also made a valuable contribution to geology in his researches on the Galapagos Islands, the well-known haunt of the giant tortoises. He conducted an expedition to the islands in 1891, and made large collections both of the animals and plants now living there. His conclusion was that the Galapagos Islands were not of the Oceanic type, as commonly supposed, but must be regarded as the peaks of mountains which once existed on a western extension of the Central American region now submerged. The Galapagos tortoises were thus to be considered as the stranded survivors of the large forms which were abundant on the American continent in the middle part of the Tertiary period.

The more important of Dr. Baur's papers having special reference to vertebrate palæontology are enumerated in the following list:—

1. "Osteologische Notizen über Reptilien," Fortsetz. i: Zool. Anz., 1886, pp. 733-743.
2. "Ueber die Homologien einiger Schädelknochen der Stegocephalen und Reptilien": Anat. Anz., 1886, pp. 348–350.
3. "On the Morphology of the Ribs": Amer. Nat., 1887, pp. 942–946.
4. "Ueber die Abstammung der amnioten Wirbelthiere": Biol. Centralbl., vol. vii (1887), pp. 481–493.
5. "On the Morphology and Origin of the Ichthyopterygia": Amer. Nat., 1887, pp. 837–840.
6. "Ueber den Ursprung der Extremitäten der Ichthyopterygia," Bericht xx: Versamml. Oberrhein. geol. Vereins, 1887, with plate.
7. "On the Phylogenetic Arrangement of the Sauropsida": Journ. Morph., vol. i (1887), pp. 93–104.
8. "Osteologische Notizen über Reptilien," Fortsetz. iii: Zool. Anz., 1888, pp. 417–424.
9. "*Palæohatteria*, Credner, and the Proganosauria": Amer. Journ. Sci., vol. xxxvii (1889), pp. 310–313.
10. "Mr. E. T. Newton on Pterosauria": Geol. Mag., Dec. III, Vol. VI (1889), pp. 171–174.
11. "The Systematic Position of *Meiolania*, Owen": Ann. Mag. Nat. Hist. [6], vol. iii (1889), pp. 54–62.
12. "On the Morphology of the Vertebrate Skull": Journ. Morph., vol. iii (1889), pp. 467–474.

13. "*Kadaliosaurus priscus*, Credner, a new Reptile from the Lower Permian of Saxony": Amer. Journ. Sci., vol. xxxviii (1889), pp. 156–158.
14. "On the Classification of the Testudinata": Amer. Nat., 1890, pp. 530–536.
15. "Die systematische Stellung von *Dermochelys*, Blainv.": Biol. Centralbl., vol. ix (1889), pp. 149–153, 180–191.
16. "Nachträgliche Bemerkungen über die systematische Stellung von *Dermochelys*, Blainv.": ibid., vol. ix (1889), pp. 617–620.
17. "The Horned Saurians of the Laramie Formation": Science, vol. xvii (1891), pp. 216, 217.
18. "Remarks on the Reptiles generally called Dinosauria": Amer. Nat., 1891, pp. 434–454.
19. "On the Relations of *Caerttochelys*, Ramsay": ibid., 1891, pp. 631–639.
20. "Notes on some little-known American Fossil Tortoises": Proc. Acad. Nat. Sci. Philad., 1891, pp. 411–430.
21. "On the Morphology of the Skull in the Mosasauridæ": Journ. Morph., vol. vii (1892), pp. 1–22, pls. i, ii.
22. "Bemerkungen über die Osteologie der Schläfengegend der höheren Wirbelthiere": Anat. Anz., vol. x (1894), pp. 315–330.
23. "Die Palatingegend der Ichthyosauria": ibid., vol. x (1894), pp. 456–459.
24. "Cope on the Temporal Part of the Skull, and on the systematic position of the Mosasauridæ: A Reply": Amer. Nat., 1895, pp. 998–1002.
25. "The Paroccipital of the Squamata and the Affinities of the Mosasauridæ once more": ibid., 1896, pp. 143–147, pl. iv.
26. "The Stegocephali": Anat. Anz., vol. xi (1896), pp. 657–673.
27. "Bemerkungen über die Phylogenie der Schildkröten": ibid., vol. xii (1896), pp. 561–570.
28. [With E. C. Case.] "On the Morphology of the Skull of the Pelycosauria and the Origin of the Mammals": ibid., vol. xiii (1897), pp. 109–120.
29. "Ueber die systematische Stellung der Microsaurier": ibid., vol. xiv (1897), pp. 148–151.
30. "Archegosaurus": Amer. Nat., 1897, pp. 875–980.

JOHN CARRICK MOORE, M.A., F.R.S., F.G.S.

Born 1804. Died February 10, 1898.

By the death of John Carrick Moore, science loses the last of that band of ardent field-geologists who, during the first half of the present century, did so much to investigate the underground structure of the British Islands. Inspired by the example and animated by the scientific principles of William Smith, they carried out in fuller detail than was possible to their master, his great idea of delineating in maps and sections the distribution and relations of the British strata, guided everywhere by the organic remains which they contain. But while this band of workers—which included such names as those of Buckland, Conybeare, Webster, Mantell, Dixon, Lonsdale, Sedgwick, Murchison, Fitton, De la Beche, Godwin-Austen, and Phillips—were so deeply influenced by the teaching of William Smith, yet they were seldom, with the exception of the last-mentioned, personally instructed by him, but derived their knowledge of his principles and methods at second-hand from men like Richardson, Townsend, and Farey, who were proud to act as the disciples and interpreters of the distinguished "Father of English Geology."

John Carrick Moore came of a famous stock. His grandfather, Dr. John Moore, the friend and biographer of Smollett, was the author of many well-known works, of which the novel "Zeluco" has been longest remembered. Three of the sons of Dr. John Moore

had very distinguished careers. The eldest surviving son was General Sir John Moore, the hero of Corunna, and a younger son was Admiral Sir Graham Moore, whose exploits on the sea were scarcely less notable than those of his elder brother in the field. The father of John Carrick Moore was James Moore, the second surviving son of Dr. John Moore, who studied medicine in Edinburgh and London, and became one of the most distinguished surgeons of his day. He was the friend of Jenner, and, as a well-known writer in favour of vaccination, was appointed to succeed that surgeon as director of vaccine establishments.

James Moore, who practised extensively for many years in London, was the author of various medical treatises and of a biography of his brother, General Sir John Moore, published in 1833. Having had bequeathed to him by a Mr. Carrick, a banker in Glasgow, the estate of Corsewall, in Wigtownshire, near Stanraer and Port Patrick, James Moore added to his own surname that of Carrick. In 1825 James Carrick Moore retired from practice, and, having built himself an excellent house upon his estate on the shores of Loch Ryan, spent the remainder of his life there, dying in 1834 at the age of 71. On their mother's side, the Moores were descended from Robert Simson, the celebrated geometrician.

John Carrick Moore was the second son of James Carrick Moore, and was born in 1804. He went to Cambridge, and was educated at Queen's College, proceeding to the degree of M.A., and devoting much attention to mathematics and physics. Before the year 1838, his attention seems to have been attracted by the rocks of the Rhinns of Wigtownshire, near his residence, for we find that he was in communication with Charles Lyell, who identified the fossils found by him as graptolites. In the year named, he was elected a Fellow of the Geological Society.

In 1839 he traced out carefully the succession of strata along the west shore of Loch Ryan, and in the following year a paper on the subject was read by him to the Geological Society. In 1841, Sedgwick, crossing from Ireland, paid a visit to Corsewall, and was accompanied by John Carrick Moore in a tour through Ayrshire. In September, 1843, Lyell and his wife paid a visit to the same hospitable dwelling, examining and confirming the accuracy of Moore's sections. Much of Lyell's time seems to have been spent in studying the rain- and hail-prints, with the fucoid- and crustacean-markings on the shores of Loch Ryan, and he subsequently wrote to Moore: "The Loch is a grand magazine of geological analogies—tidal, littoral, conchological, sedimentary, etc., which I envy you having at your door." Subsequently to this visit, Lyell, under the direction of Moore, visited the remarkable rocks in the neighbourhood of Ballantrae, and bore testimony to the accuracy of his friend's work there.

In 1846 we find John Carrick Moore had become so identified with the work of the Geological Society that he was elected Secretary, and in the same year he became a member of the Geological Society Club. He held the office of Secretary for six years (1846–52), when

he was elected a Vice-President of the Society (1853–4), resuming his post of Secretary in 1855 for one year. So active, indeed, was Carrick Moore in the administration of the Geological Society's affairs, that between 1846 and 1875 we find him absent from the Council only in four years; he was a Vice-President in 1862, and again in 1864–5. In 1848 he read a more extended paper to the Geological Society on the Silurian rocks of the Wigtownshire coast, the fossils being described and figured by Salter. In 1856 and 1858 Moore communicated accounts of further observations on Wigtownshire geology to the Geological Society, while his general interest in geological research was shown by the papers written by him in 1850 and in 1863, on fossils collected and sent home from San Domingo by Mr. Heniker, and from Jamaica by Lucas Barrett. In 1849 we find him describing the Oligocene fossils found in the New Forest.

John Carrick Moore was proposed as a Fellow of the Royal Society in November, 1855, his nomination paper being signed first by his friend Charles Lyell, while others who subscribed from personal knowledge were Sedgwick, Murchison, Hopkins, Leonard Horner, and Faraday. He does not appear, however, to have ever contributed a paper to the Society. By his patient labours in studying the geology of Galloway he made valuable additions to our knowledge of the stratified rocks of Britain, and he took a distinguished place among the band of amateur workers—including many landed proprietors, clergymen, soldiers, and doctors—to whose painstaking and detailed work in the field English geology owes so much. Among these men, John Carrick Moore was always held in the highest esteem, and his time and energy were ungrudgingly devoted alike to the advancement of his favourite science by careful studies in the field, and to the promotion of the interests of the Society identified with that science, during the parts of the year when he resided in London.

In 1864 Andrew Ramsay spent a few days with John Carrick Moore at Corsewall, mapping the peninsula which terminates in Corsewall Point, for the Geological Survey of Scotland. Of John Carrick Moore's wide sympathies with all matters connected with geology, and of the knowledge and ability with which, owing to his early training at Cambridge, he was able to deal with those questions of physical geology demanding an acquaintance with mathematical methods, we have abundant evidence. Between 1865 and 1867 he sent a series of letters to the Philosophical Magazine, dealing in a very able and critical manner with Ramsay's theory of the origin of lake-basins, and with Croll's theory of the cause of the Glacial Period. These letters show that Moore had not forgotten his early training, and had kept himself abreast of the science of the day by his studies of physical questions; and the substantial justice of his criticisms has been abundantly shown by later researches. In 1875 he wrote to *Nature*, pointing out a curious oversight of Humboldt in his "Cosmos."

In 1875 John Carrick Moore finally withdrew from the Council of the Geological Society, upon which he had served so long and so

faithfully; and from that time forward he would seem to have ceased to take any active part in scientific work. Few of the present generation of geologists can even recollect having seen the stately and courteous gentleman, who was at one time so indefatigable in the service of their Society, and who had so frequently acted as one of its officials. For nearly a quarter of a century after this withdrawal from public activity, however, John Carrick Moore lived on, spending his time between his seat in Wigtownshire and the house in Eaton Square, where he died on February 10, 1898, at the great age of 94. His only son had predeceased him, but a daughter survives, the estate passing to his nephew Colonel Sir David Carrick Buchanan, of Drumpellier. Besides the Corsewall estate, John Carrick Moore owned property in Kirkcudbrightshire and in England, and he was a Deputy-Lieutenant of the county of Wigtownshire. He was not less highly respected among the gentry of his county and the tenants of his estate than in the circles of scientific society in London, in which his presence was so long conspicuous. J. W. J.[1]

MISCELLANEOUS.

The Hereford Earthquake of December 17th, 1896.—A report on this important earthquake by Dr. Charles Davison, F.G.S., will be published in the autumn, if a sufficient number of subscriptions be obtained to defray the cost of printing. The work is founded on nearly 3,000 observations made at places distributed over an area of about 100,000 square miles. This area exceeds that disturbed by any other known British earthquake, and includes every county in England but three, the whole of Wales, the Isle of Man, and the eastern counties of Ireland. Copies of the prospectus may be obtained from Messrs. Cornish Bros., 37, New Street, Birmingham.

Ossiferous Caves in the Basque Country (Bayonne).—Mr. George Greenwood, Broadhanger, Petersfield, Hants, lately visited the ossiferous caves at Isturitz, Hasparren, in the Basque country (Bayonne), and brought away specimens of the teeth of the Great Cave Bear *Ursus spelæus*, Horse, and Ibex. The deposits are so rich in mammalian remains that the proprietor is working them for the purpose of selling the deposit for manufacturing bone-manure for the farmers. It is to be regretted that no effort is being made to save the splendid specimens of the Cave Bear and other animals, as well as remains of primitive man, which these caverns afford. Could not a committee of the British Association under Section C take the matter up, and obtain a grant to work these interesting caves? Monsieur Roth, of Bayonne, is the only gentleman in the neighbourhood with scientific tastes who might be induced to help in such a good work.—Old Bones.

[1] Proceedings of the Royal Society, vol. lxiii.